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ASTM BULLETIN

Published by
AMERICAN SOCIETY for TESTING MATERIALS

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AUGUST—1942

No. 117

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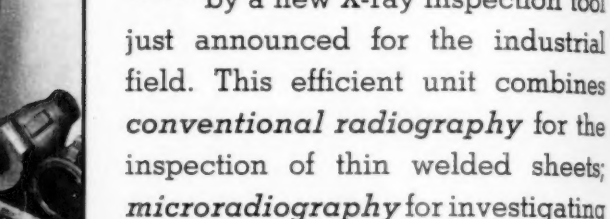
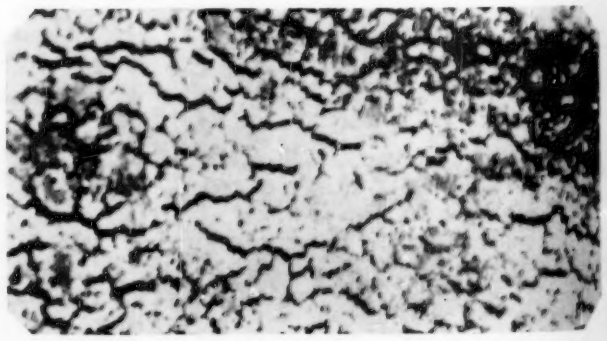


The figure shown above was secured by means of this new multi-purpose X-ray unit. It shows three diffraction patterns of one sample of steel. On the left, the molecules are arranged haphazardly and under great strain. After partial annealing, the center pattern is obtained, the molecules having rearranged themselves in a more symmetrical fashion. After complete annealing, the pattern on the right indicates all strain has been relieved.



A microradiograph of cartridge brass taken with this new X-ray unit shows season cracks. The relative density of shadows indicates whether cracks extend partially or all the way through the specimen.

PIONEER CREATORS OF *QUALITY* X-RAY EQUIPMENT SINCE 1900

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 R. E. Hess, Editor CABLE ADDRESS—TESTING

R. J. Painter, Associate Editor

Number 117 August, 1942

Large Attendance at Annual Meeting

Important Actions on Standards and Research; Outstanding Technical Sessions

ADVANCE ESTIMATES of the total registration for the 1942 meeting held in Atlantic City ranged from 700 to 1100, and no one felt that it would reach near 1400, so that the total of 1376 registered members, committee members, and guests is a very significant figure. This does not include ladies and members of families, of whom over 200 registered.

A good registration is not the most important item at an annual meeting; what has been accomplished in the interest of those producing and purchasing materials is the major consideration. From information given later in this article it will be noted that there were many important standardization accomplishments and that technical sessions brought forth many valuable papers and reports all of which will be published in the *Proceedings* or special technical volumes.

Referring to registration for a moment—for the first two days of the meeting, it totaled 1095, higher than for any other meeting, but fell off on the ensuing days so that the final figure is below that of 1940 in Atlantic City (1441) and last year's meeting in Chicago (1553).

OUTSTANDING SESSIONS

Several of the 16 formal technical sessions were notable, not only for the formal papers and reports scheduled, but for discussion and the attendance. Two of the most interesting features were in the form of a round-table discussion—one on solvent action of water vapor at high temperature and pressure with leading authorities forming the panel; the other on alternate alloy steels and conservation of strategic alloys, with prominent metallurgical authorities participating (see page 29 for details).

Max Hecht, Adviser, Power Stations Chemistry, Pittsburgh, Pa., and chairman of the Society's Committee D-19 on Water for Industrial Uses, presided during the discussion on water vapor, and John Mitchell, Metallurgical Engineer, Alloy Division, Carnegie-Illinois Steel Corp., was chairman of the alternate steels round table. Both of these men had developed the session and consequently were very close to the topics discussed, and by their guidance added considerably to the success of the affairs. There was an attendance of about 500 in the session on alternate steels.

Perhaps the outstanding technical feature at the meeting was the Symposium on Radiography in three sessions with thirteen technical papers. Lars Thomassen, Associate Professor, Department of Chemical and Metallurgical Engineering, University of Michigan, was chairman of the group in Committee E-7 on Radiographic Testing which arranged for the papers and handled other details. Announcement is made later in this BULLETIN of the contemplated publication in a special volume of these symposium papers.

BRIGADIER GENERAL C. D. YOUNG; PRESIDENT'S ANNUAL ADDRESS

Probably the largest attendance at any session greeted President G. E. F. Lundell and Brigadier General C. D. Young (Past-President, A.S.T.M.) for their addresses in the general session on Wednesday evening. General Young, now Chief of Procurement and Distribution, Services of Supply, U. S. Army, was introduced by presiding officer Dr. T. G. Delbridge who referred to his outstanding earlier work in the Society and his affiliation as vice-president in charge of real estate, purchases, and stores, Pennsylvania Railroad Co.

General Young spoke informally and off the record, giving some information on many problems confronting the services of supply. He referred to the three major Army components—the ground forces, air forces, and services of supply. The Chief of the Services of Supply gives directions to eight other main services, including Ordnance, Quartermaster General, Surgeon General, Signal Corps, Transportation, Chemical Warfare, etc. He detailed one of these branches—Ordnance—with which so many A.S.T.M. people are in contact. One idea of the tremendous production was the figure of $24,000,000,000 authorized for expenditure in the Ordnance Department. He mentioned that production was running anywhere from 25 to 55 per cent ahead of the designed capacity, due to a number of stimulating causes, one of which was definitely *not* the number of scarce strategic materials, which before the war started were in the neighborhood of twelve and now in excess of 400. He stressed the importance of steel as a substitute for copper in certain projectiles, mentioned the necessity of stimulating research on so-called "syn-

New President,
H. J. Ball

Edgar Marburg Lecturer, Dr. Graham Edgar and Retiring President, Dr. G. E. F. Lundell

thetic rubber," and also the various substitutes for alloys requiring nickel, chromium, tungsten, vanadium, and related materials. He referred to the tremendous distribution problems involved in the work and stated that remarkable progress had been made in reducing the time from production to point of use, in which activity many men from various branches of industry have contributed.

In a notable address the retiring president, Dr. G. E. F. Lundell, Chief, Chemistry Division, National Bureau of Standards, discussed chemical requirements and chemical analysis outlining various observations based on his quarter of a century experiences in this field both in A.S.T.M. and in broader aspects. The operations can be divided into those that make the determination possible and those that attend the determination itself and often in an applied analysis the former is more important. He feels that it would be helpful to the understanding of analytical chemistry if the term "chemical analysis" were applied to true analysis and if courses in so-called analytical chemistry were properly labeled. He referred briefly to the pioneering work in this field of the Society's first president, Dr. C. B. Dudley.

Dr. Lundell stressed the importance of standard samples, crediting the American Foundrymen's Assn. through Dr. Moldenke for the early work which resulted in asking the National Bureau of Standards for assistance which has now grown to be a very important part of the Bureau's technical service.

A considerable part of the address was devoted to precision and accuracy explanations, with examples of how incongruous some requirements are compared with personal errors and apparatus capacities. He decried the use of the requirements "none" as applied to "Other Impurities" or for "Total Other Impurities," since if the analyst takes these requirements seriously and starts searches, there is no limit to what he may uncover. It is the exception to find less than a dozen elements in any metal.

As an example of the saving in time which the analyst has achieved, he quoted from a famous address of over 50 years ago which stated that a chemist was expected to arrive at results in 8 or 10 hours which 20 years ago would have taken 2 weeks. Today instead of 8 or 10 hours the time required is closer to 8 or 10 minutes with more accurate results. He stated, "The analyst can claim with pride that the shortening of the time required for chemical analyses has played no small part in the evolution of our manufacturing processes." Two developments received special mention: "the rise and importance of spectrographic procedures in qualitative and quantitative analysis in the inorganic field, and of microanalysis in the organic field."

Copies of the printed presidential address, which was given by Dr. Lundell somewhat in abstract, were distributed at the close of the meeting, and any members and others interested in obtaining a copy can procure one without charge on request to A.S.T.M. Headquarters. This address will of course be published in the annual *Proceedings*.

Marburg Lecture on Gasoline—Past, Present, and Future

Over 500 of the A.S.T.M. members and annual meeting visitors attended the Edgar Marburg Lecture by Dr. Graham Edgar on "Gasoline—Past, Present, and Future." In this he stressed those properties which are extremely significant and have greatest bearing on the suitability of gasoline for internal combustion engines (namely, volatility, distillation, vapor pressure, and knocking tendencies). While the distillation test is relatively simple, the data can be used for calculating nearly all the volatility characteristics.

Although the tendency of gasoline to knock is probably its most important single property, Dr. Edgar stated that

New
Vice-President,
P. H. Bates

R. H. Titley and R. J. Carlson, Public Service Electric and Gas Co. A. Skett, American Gum Importers Laboratories, Inc.; G. Woodward, Archer-Daniels-Midland Co.; M. S. Herbert and D. Dawson, Krebs Pigment and Color Corp. T. R. Donlon, Standard Alcohol Co.; C. H. Sample and H. G. Arlt, Bell Telephone Laboratories, Inc.

this had been one of the most difficult problems confronting the Society. He then listed a summary of the best technical opinions concerning the available tests including the A.S.T.M.-CFR.

In discussing the A.S.T.M. definition of gasoline, he stressed the important words, "suitable for use . . . in internal combustion engines," since gasoline properties are inseparably linked with the engine properties.

Concerning gasoline chemistry, he indicated the stress that has been focused upon research, in a large part an outcome of knock studies since this is related directly to the chemical composition, and mentioned that our knowledge of hydrocarbons has led to advances in many fields other than gasoline. After outlining the current gasoline situation, he discussed postwar gasoline tying this in with the important part aviation will probably play in transportation. He stated that "one might guess that gasoline approximately equivalent to the premium grade of 1941 (say, 80 octane) could be produced as a housebrand gasoline and that premium gasoline having effective antiknock values of between 90 and 100 octane number could be produced."

In conclusion he again stressed the very close relation between the petroleum and automotive industry as inseparable parts of the same industry, transportation, which parts must progress simultaneously if the public is to receive "the more efficient, more economical, more comfortable, and safer transportation which appears to be definitely technically and economically possible."

Standardization Accomplishments

Normally in the year when the Book of Standards is being published the annual meeting is asked by the standing committees to act on a very large number of items. It will be seen from the accompanying table that there were many actions taken, but the total number is somewhat below that of previous comparable years. This situation is undoubtedly due to the fact that in the last three years the Society's regulations have been changed and the committees have followed through closely in seeing that tentative standards are adopted as standard somewhat sooner than used to be the practice when many of these actions were saved for Book of Standards' year.

Nevertheless, many of the actions taken were extremely significant and it will be seen that there were some 68 new tentative standards, many of which meet important needs. Details of some of these new tentative standards are incorporated in this Bulletin.

From the accompanying table it will be observed that upward of 60 revisions of existing tentative standards were approved and more than 70 existing tentative standards were recommended for adoption as formal standard. In addition many revisions are being adopted in standards. Depending upon the result of these actions in Society letter ballot and also upon any actions which may be approved in the meantime by the Committee on Standards, the Society will have on its books as of September 1 close to 1100 specifications and tests which is a net increase over the same period of a year ago of about 80.

In a separate mailing there is being sent to each member a letter ballot covering those actions involving the adoption of standards or changes in existing ones, this ballot being accompanied as customary by the *Summary of Proceedings* which gives detailed information on matters covered in the ballot, particularly any changes made at the meeting.

Dudley Medal Award; Thompson Award

The Sixteenth Award of the Charles B. Dudley Medal, which was established to commemorate the name of the

SUMMARY OF ACTIONS TAKEN AT ANNUAL MEETING AFFECTING STANDARDS AND TENTATIVE STANDARDS.

	Existing Tentative Standards Adopted as Standard	Standards in Which Revisions Will Be Adopted	New Tentative Standards	Proposed Revisions of Existing Standards Accepted as Tentative	Existing Tentative Standards Revised	Standards and Tentative Standards Withdrawn or Replaced	Present Total Standards Adopted	Present Total Tentative Standards
A. Ferrous Metals—Steel, Cast Iron, Wrought Iron, Alloys, etc.	12	33	4	..	6	4	157	30
B. Non-Ferrous Metals—Copper, Zinc, Lead, Aluminum, Alloys, etc.	6	9	4	..	29	8	54	97
C. Cement, Lime, Gypsum, Concrete, and Clay Products	5	26	8	3	4	3	115	44
D. Paints, Petroleum Products, Paper, Textiles, Rubber, Soap, etc.	40	36	45	5	21	10	355	196
E. Miscellaneous Subjects, Testing, etc.	9	2	7	..	1	..	18	21
Total	72	106	68	8	61	25	699	387

Don M. McCutcheon, Ford Motor Co.; R. J. Van de Graaff, Massachusetts Institute of Technology. T. G. Stitt, Pittsburgh Steel Co.; L. H. Fry, Edgewater Steel Co. G. E. Baumgardner, Norfolk & Western Railway Co.; G. J. Durant, Froehling and Robertson, Inc.; A. T. Goldbeck, National Crushed Stone Assn., Inc. Mr. and Mrs. F. M. Howell, Aluminum Co. of America

first President of the Society and is awarded each year to the author or authors of a paper constituting an original contribution on research in engineering materials, was made to F. C. Todd, Assistant Professor, Petroleum and Natural Gas Engineering, and A. W. Gauger, Director, Mineral Industries Research, The Pennsylvania State College, for their paper presented at the 1941 Annual Meeting on "Studies on the Measurement of Water Vapor in Gases." In response for Professor Todd and himself, Doctor Gauger expressed gratitude and also mentioned that this work was part of the activities of a relatively new committee, D-3 on Gaseous Fuels, the members of which he said, "had been our best friends and our severest critics."

The Third Sanford E. Thompson Award which was established by Committee C-9 on Concrete and Concrete Aggregates was made to John Tucker, Jr., Chief, Concreting Materials Section, National Bureau of Standards, for his paper on "Statistical Theory of the Effect of Dimensions and of Method of Loading Upon the Modulus of Rupture of Beams" presented before the Society at the 1942 Annual Meeting.

Symposium on Radiography Focuses Attention on Vital Subject

The Symposium on Radiography which was arranged by Committee E-7 on Radiographic Testing, headed by H. H. Lester, Watertown Arsenal, will, when published later in the summer, acquaint the engineering profession with the most recent developments in X-ray and radium radiography of engineering materials. Since 1936 when the Society held its first symposium on this subject resulting in a 350-page publication, the first of its kind in the English language, there have been phenomenal increases in applied voltage, more extended use of radium, and a much wider diversification of products investigated by these testing methods.

In the discussion of radiography of welds and weldments, it was indicated that much of the present-day production speed has resulted from welding, which in turn has greatly increased the number of radiographic testing units in use not only in the pressure vessel field but for spot checks in other structural welds. Similarly, the field of gamma-ray radiography is expanding. Also explained were some of the advantages of the million-volt X-ray unit.

Two of the papers involved the field of magnesium alloys, one giving calibration data and scatter measurements for radiography of magnesium aircraft castings, and the other, correlation of the mechanical properties and radiographic appearance of magnesium alloy castings. Dr. L. W. Ball of the National Research Council of Canada stated that direct tests of relative sensitivity obtained with magnesium and pure aluminum give very similar results which would refute the belief that magnesium is difficult to radiograph. A possible factor in this situation is that possibly the low kilovoltage required to compensate for magnesium's low density has not often been available.

There was discussion of gamma-ray radiography of welded high-pressure power plant piping with some excellent illustrations of results achieved and successful technical methods that have been employed. One of the very interesting papers considered contrast and latitude in steel casting radiography with million-volt X-rays. The author traced steps by which radiographic contrast and factors can be obtained from which can be predetermined the voltage, film, and related essentials that should be used to give the desired results. Another paper covered in detail the apparatus used in radium radiography.

Personnel from the Naval Research Laboratory described an exposure meter for X-ray radiography for different brands of film and screen calibrations and the time required for any desired results. The receiving element of the exposure meter is a Geiger-Müller counter designed to permit accurate intensity determinations in a few seconds, with the measured beam of radiation limited to a pencil of X-rays, one quarter of an inch in diameter. Messrs. Schier and Doan of Lehigh University reported on further studies involving precision radiography in which an equation had been developed giving the minimum radiography required for adequate definition of the penetrameter required in the A.S.M.E. boiler code. Another paper by the same authors described equivalent penetrameters in radiographic testing. One of the very interesting contributions was a description of a million-volt portable X-ray unit which permits radiography from 10 to several hundred times faster than older equipment through masses of steel ranging from $1/4$ to 8 in. in thickness with radiographic definitions of 1 to 2 per cent.

Session on Water and Solvent Action of Water Vapor

As indicated, the session devoted to the subject of water included the Round-Table Discussion on the Solvent Action of Water Vapor at High Temperature and Pressure, which evoked considerable discussion. Committee D-19 on Water for Industrial Uses in its report recommended the adoption as standard of the three existing tentative methods covering the determination of the following ions:

calcium, magnesium, chloride, and sulfate. Studies are under way on methods of sampling and a preliminary questionnaire showed a wide diversity of individual methods, but further information is being developed which it is hoped will lead to some recommended standard procedure of sampling water and condensed steam from equipment.

Many leading authorities participated in the round table, following an introduction by G. W. Morey, formerly of the Geophysical Laboratory, Carnegie Institution. In connection with scale or salt deposits on the interior surfaces of steam turbines, it was pointed out that this is of much concern, since any condition that lowers the efficiency or capacity of a product or may endanger its life warrants attention. The turbine builder has been studying designs to see if he can help, but selection of material does not seem to offer great assistance; therefore, the operator has found what relief there is or at least a partial answer to some problems through study with the boiler manufacturer or water treating experts. Another turbine builder felt that the matter was a problem for cooperative research, but in which the turbine builder would undoubtedly join in any helpful way possible.

One of the discussers, covering solubility of boiler water salts and superheater steam, has made practical use of a theory of turbine blade deposits. The salts seem to deposit in order of solubility and therefore should redissolve as the temperature is increased above the solution point. Sodium sulfate, for example, requires a much higher temperature for removal than quartz. The author indicated that experience with this application had been satisfactory, and topping turbines have been maintained free from deposits by periodically increasing temperature for short periods for lower stages, but he stated that more fundamental data are required in preventing occurrence of deposits.

A discussion of solids in steam by one speaker was summarized as follows: (1) Pressure or temperature, or both apparently affect the manner in which solids are carried by steam, *i.e.*, mechanical or in solution; (2) concentration or amount of any one solid in boiler water or steam is not the deciding factor of whether deposits will form; (3) apparently some other deciding factor such as ratio of the various ordinary boiler water solids to each other determines stickiness of solids in steam.

Important Committee Reports

The palm for outstanding committee activities in developing new standards this year will go to those in the "D" group, including Committees D-13 on Textile Materials, D-1 on Paint, Varnish, Lacquer, and Related Products, D-6 on Paper and Paper Products, and D-20 on Plastics, which between them accounted for 23 of the new standards proposed, D-13 alone having eight.

> A list of new tentative standards, with newly assigned serial designations, appears on another page of this Bulletin, and there is also a list of the standards which were withdrawn.

Steel.—This year there were not so many recommendations coming from the committees in the A (ferrous metals) group, although Committee A-1 on Steel is making changes in a large number of its standards. Two new tentative standards were approved at the meeting covering copper brazed tubing and welded alloy open-hearth iron pipe, but perhaps of most significance, at least in the field of pipe and tubing, was the adoption of a new method of determining elongation values which is based on pipe wall thickness, and a new formula for determining flattening test requirements which establishes rational values based on pipe size and grades, these changes both being effective in two of the Society's most basic specifications, A 53 covering welded and seamless steel pipe, and A 106 lap-welded and seamless steel pipe for high-temperature service. These two specifications will also permit electric-resistance-welded pipe, and a matter which has received considerable attention to allow the use of acid-bessemer steel for seamless material, was approved.

Cast Iron.—Committee A-3 on Cast Iron had approved a new procedure covering compression testing of cast iron and expects to submit during the summer a recommended practice of making torsion tests.

Copper and Copper-Alloy Wires for Electrical Conductors.—Committee B-1, which developed the Emergency Specification ES-1 covering lead-coated and lead-alloy-coated copper wire for electrical purposes, submitted three specifications covering bunch-stranded copper conductors, rope-lay-stranded copper conductors with bunch-stranded members, and rope-lay-stranded copper conductors with concentric stranded members. These are intended to replace existing Specifications B 158 covering rope-lay-stranded and bunch-stranded copper cables for electrical conductors. Also completed by the committee and to be published as information and comment are specification requirements covering tinned hard and medium hard-drawn copper wire.

Electrical-Heating, Resistance Alloys.—Committee B-4 on

W. Romanoff, H. Kramer and Co.; J. W. Bolton, The Lunkenheimer Co. J. O. Leech, Carnegie-Illinois Steel Corp.; O. U. Cook, Tennessee Coal, Iron and Railroad Co. H. M. Hancock, The Atlantic Refining Co.; E. W. Dean, Standard Oil Development Co. R. P. Nevers, American Brass Co.; F. M. Barry, The Scovill Manufacturing Co.

Electrical-Heating, Electrical-Resistance, and Electric-Furnace Alloys had its proposed specification approved covering round nickel wire for lamps and electronic devices, and also submitted completely revised tests for nickel alloy wire and ribbon, and for testing lateral wire for grids and electronic devices.

Cementitious Materials.—Of particular interest in the field of cementitious materials were new tentative specifications not published in the report covering two types of portland cement treated for use in concrete pavements exposed to severe frost action. The two types are designated Ia and IIa and correspond, respectively, to Types I and II of Standard Specifications for Portland Cement (C 150 – 41).

Concrete and Concrete Aggregates.—Committee C-9 on Concrete and Concrete Aggregates completed a very active year and the annual meeting approved its recommendations for four new tentative standards: specifications for waterproof paper for curing concrete, and three new test methods covering sampling of fresh concrete, measuring length of drilled concrete cores, and test for air content of freshly mixed concrete were recommended. The sampling method covers procedure for obtaining materials from mixers, hoppers, or transportation units. The method of measuring length of drilled concrete cores is based on very extended research in one of the subcommittees and the project report prepared by L. W. Teller, explained the work that had been done which involved studies of questionnaires, actual test work, etc. To insure the necessary degree of accuracy, each specimen length should be determined by averaging not less than nine well distributed measurements.

Thermal Insulating Materials.—While not prepared to present a number of recommendations, Committee C-16 on Thermal Insulating Materials' action approved at the meeting covering a new tentative method of test for thermal conductivity of materials by means of the guarded hot plate is outstanding. This has been under development in a Joint Committee for some time. With the test was extended discussion by F. C. Houghten, Chairman of the Joint Committee, in which he gave considerable data on the test program and results. Before the method was referred to the Society, a series of tests was conducted in six laboratories which followed procedures conforming to the test. In all cases the results were in satisfactory agreement.

Paint, Varnish, Lacquer, and Related Products.—Committee D-1 recommended five new tentative standards including specifications for a red pigment commercially known as chemically pure toluidine toner and specifications covering five types of lead chromate pigments. Two of the new tentative tests are to replace existing standards, one covering spectral characteristics and color of objects and materials which is based on the use of the spectrophotometer. The method of consistency of exterior house paints and enamel type paints makes use of the Stormer viscosimeter with the paddle-type rotor. By this method consistency is expressed in terms of weight required to produce the specified speed. Perhaps of most interest was the new test for abrasion resistance of organic coatings with the air blast abrasion tester which is made on organic coatings when applied to flat sheet metals. Full details of the equipment and procedure are given.

Petroleum Products and Lubricants.—An outstanding report was presented to the Society for action by Committee D-2 on Petroleum Products and Lubricants, this being one of the most extensive reports given at the meeting. Three new tentative standards were accepted—one covering a test for neutralization number by color-indicator titration which indicates the presence of organic constituents having acid or basic characteristics and the contamination by strong bases and strong acids. The second covers neutralization number by electrometric titration. These two new methods replace the existing Methods D 188 which have been withdrawn.

A new test for rust-preventing characteristics of steam-turbine oil in the presence of water is intended to indicate the ability of these oils including those used for steam-turbine gears to aid in preventing the rusting of ferrous parts, should water become admixed with the oil. This standard test was based on considerable research work carried out in a special D-2 section in various cooperating laboratories. The test finally agreed on rated oils in the same order, the rating agreeing with service data.

The committee also appended to its report several proposed methods, one covering test for oil content of paraffin wax, a proposed test for color of lubricating oils with photoelectric colorimeter, another covering proposed test for potential gum in aviation gasoline which is an accelerated oxidation test. Still another method published for information covers oxidation characteristics of heavy-duty crankcase oils. This is based on the use of an oxidation test engine which is a spark ignition internal combustion engine requiring certain loading and accessory equipment.

A number of changes in various standards were acted upon including the Method of Test for Knock Characteristics of Motor Fuels (D 357 – 40) to which has been added knock intensity guide tables, and there has been editorial rearrangement.

Paper and Paper Products.—Committee D-6 on Paper and Paper Products is continuing its intensive activities and five new tentative methods of test were accepted on its recommendation and six of the previously published tentative standards are to be referred to A.S.T.M. letter ballot for adoption as standard. The new tests cover the following: Pentosans, Conditioning Paper for Testing, Quantitative Determination of Coating on Mineral-Coated Paper, Internal Tearing Resistance of Paper, Qualitative Examination of Mineral Fillers and Mineral Coatings of Paper.

Electrical Insulating Materials.—In its extensive report, Committee D-9 on Electrical Insulating Materials presented five new tentative standards—one covering sludge formation in mineral transformer oil, involving two methods, one a sludge accumulation test applicable to new, mineral transformer oils, except those that have been "stabilized" and the other, the high-pressure oxidation test, applicable to new oils except the highly refined, white oils of zero iodine value and mineral oil with additives.

The new methods of testing steatite used as electrical insulation are not to be interpreted as forming test specifications for complete insulators, but outline procedures which may be required in investigating or examining this material. Other new methods cover procedures for measuring dimensions of rigid tubes used in electrical insula-

From left to right: Harold Farmer, Philadelphia Electric Co., and C. H. Fellows, The Detroit Edison Co.; H. E. Seemann, Eastman Kodak Co., E. E. Smith, Eastman Kodak Co., and E. W. Page, General Electric X-ray Corp.; J. A. Baty, U. S. Rubber Co. and S. Collier, Johns-Manville Corp.

tion, limitations imposed being those of the size range of the more common forms of measuring instruments used.

With the test for sludge formation in mineral transformer oil was a very extensive statistical comparison of results of cooperative tests which have extended from 1926 to 1942. Committee D-9 has had a very active year and its large number of A.S.T.M. methods and specifications to be published in the 1942 Book of A.S.T.M. Standards will present the latest thoughts of the committee.

Textile Materials.—As indicated, Committee D-13 on Textile Materials occupies first place in the total number of tentative standards approved at the annual meeting with two new specifications and six test procedures. The specifications cover plain weave asbestos cloth, five grades being classified according to percentage of asbestos by weight ranging from 75 to 99 per cent; another specification is for all-cotton upholstery tapestries classified in three types, light, medium and heavy-weight material. The new test and tolerances for certain all-cotton and cotton-and-rayon fine fancy goods includes such products as combed handkerchief cloths, plain combed staples using color in warp or filling; piques and bedford cards woven on dobby looms; other dobby and jacquard weaves, carded or combed; combed shirtings, dress goods, and goods of cotton and rayon mixed yarns manufactured to purchase specifications. The type of fine staple cotton gray goods covered in these new tests and tolerances included combed broadcloth, lawns, longcloths, organdies, oxfords, pongees, poplins, voiles, piques, bedford cords woven on plain looms, and sateens and twills all or partly combed. The desirability of having the standard testing procedures for plied jute yarn and single and plied jute rove, both treated and untreated for electrical and packing purposes, resulted in a new tentative standard, which was developed by Subcommittee A-5 on Bast and Leaf Fibers and Their Products. Other new tests in this field included one for colorfastness to atmospheric gases of dyed cellulose acetate rayon and qualitative procedure for identification of various finishes on cotton textiles. The eighth new method developed by Committee D-13 in that phase of its work involving bleaching, dyeing, and finishing is the test for resistance of textile fabrics to microorganisms covering an accelerated mildew infection method and soil burial method.

Plastics.—There is probably no A.S.T.M. committee that has had many more round-robin cooperative tests and investigative work under way than Committee D-20 on Plastics. Including the five new tentative standards, all of them tests, approved at the annual meeting this committee has now 18 standards in its charge. Since the emergency has intensified the interest in plastics, the committee has accelerated its activities in an effort to supply industry and the Government with standard requirements. The new tests cover the following subjects: repeated flexural stress fatigue, mar resistance, long-time tension test, haze, descriptive nomenclature for objects made from plastics.

The fatigue test is applicable to plastic impregnated wood and plastic bonded plywood and is designed to evaluate the fatigue stress of materials and give reliable data for design. The so-called mar resistance method covers the resistance of glossy surface to abrasive action. This involves the measurement of progressive optical deterioration and is applicable to molded and laminated plastics, paint films, and plated coatings. Essentially, the method involves the optical measurement of gloss of spots which have been abraded by material applied in a specified manner. A technical paper on this subject described a number of studies, with results given for a variety of materials both plastic and nonplastic.

The widespread use of certain types of plastics in windshields and related applications makes the new method of test for determining haze very pertinent. The method uses a special haze meter which by photoelectric equipment measures haze using specimens with parallel faces. By the method qualitative values can be obtained of imperfections such as surface scratches, internal particles, and other defects.

Dr. and Mrs. A. H. White, University of Michigan. T. D. Parker, Climax Molybdenum Co.; E. K. Mull, Bendix Radio Corp.; Roger Metzler, Bendix Aviation Corp. J. L. Miner, Atlas Lumnite Cement Co.; W. M. Kinney, Portland Cement Assn.; Myron Park Davis, Otis Elevator Co.

Lawford H. Fry | R. P. Anderson | Alexander Foster, Jr. | J. H. Foote | M. H. Bigelow

NEW OFFICERS

THE RECENT ELECTION of officers, as announced at the annual meeting by the tellers, resulted in the unanimous election of H. J. Ball as President (1942–1943), P. H. Bates as Vice-President (1942–1944), and the following as members of the Executive Committee (1942–1944): R. P. Anderson, Maurice H. Bigelow, J. H. Foote, Alexander Foster, Jr., and Lawford H. Fry.

PRESIDENT

H. J. Ball, the new President, Professor of Textile Engineering, Lowell Textile Institute, Lowell, Mass., received his B.S. degree in Mechanical Engineering from the Massachusetts Institute of Technology in 1906. Later he completed a course in Professional Accountancy and received the degree of B.C.S. (with honor) in 1916 from Northeastern University. A member of the faculty at Lowell from 1906 to 1918, he was made head of the Textile Engineering Department in the latter year. As an active member and Chairman since 1930 of one of the Society's largest and most active committees, Committee D-13 on Textile Materials, he has contributed notably to the advancement of standardization and research work in this field. During the years that he has been chairman, some of the committee's outstanding accomplishments have been made. He was a member of the Society's Executive Committee from 1934 to 1936 and again from 1939 to 1940. He served as Vice-President of the Society from 1940 to 1942. He also rendered service as a member of Committee E-6 on Papers and Publications. In addition to the A.S.T.M. he holds membership in the American Society of Mechanical Engineers, Textile Research Institute, Inc., and the British Textile Institute, Inc.

VICE-PRESIDENT

P. H. Bates, Chief, Clay and Silicate Products Division, National Bureau of Standards, Washington, D. C., after graduating from the University of Pennsylvania, class of 1902, became Assistant Chemist, Pennsylvania Railroad, serving until 1906. He then became Chemist, Technologic Branch, U. S. Geological Survey at St. Louis, and from 1910 to 1919 was in charge of the Pittsburgh Branch of the National Bureau of Standards. During the next two years he was Chief, Structural Miscellaneous Materials Division, at the Bureau, and also Acting Chief, Ceramic Division. He has been in his present position since 1921. Mr. Bates has been chairman of A.S.T.M. Committee C-1 on Cement since 1926 and has been active in other Society work. He is a past-president of the American Concrete Institute, and was awarded the Turner Medal by the Institute in 1939 for contributions to science, direction of research, and outstanding leadership in advancing the intelligent utilization of cement and concrete. In 1940 he was the A.S.T.M. Edgar Marburg Lecturer on the subject, "Portland Cement—Theories (Proven and Otherwise) and Specifications."

MEMBERS OF EXECUTIVE COMMITTEE

R. P. Anderson, Secretary, Division of Refining, American Petroleum Institute, New York, N. Y., was graduated from Cornell University, receiving his A.B. degree in 1908 and Ph.D. in 1912. He served as Assistant Instructor, Instructor, and Assistant Professor in Chemistry, 1907 to 1917; then was Chief Chemist, United Natural Gas Co., Oil City, Pa., until 1924; Technologist, American Petroleum Institute, 1924 to 1931, and since 1931 has been Secretary, Division of Refining, American Petroleum Institute. During World War I, he was Captain, Chemical Warfare Service, stationed at Perteaux, France (1918–1919). In 1933, Doctor Anderson was Delegate, U. S. Government, to First World Petroleum Congress in London. He has been Secretary of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants since 1925 and serves on the Advisory Committee of Committee E-8 on Nomenclature and Definitions. He was a member of the Society's Committee E-10 on Standards from 1935 to 1941; chairman, 1939 to 1941. He is a member of the Board of Directors of the American Standards Association, and past-chairman of the A.S.A. Standards Council. Doctor Anderson is a member of the American Chemical Society, a Fellow of the A.A.A.S., and is a member of Sigma XI and Gamma Alpha.

Maurice H. Bigelow, Director of Technical Service, Plaskon Co., Inc., Toledo, Ohio, received his early education in the Concord (Mass.) schools following which he obtained his B.S. degree in Chemical Engineering at Northeastern University, Boston. Shortly thereafter he became head of the Science Department of an American college in Salonica, Greece. He spent four years in Europe, much of the time in geological and archeological surveys. After returning to America he was enrolled at the University of Pittsburgh as assistant instructor, and in 1933 received a doctorate in chemistry. In 1933 he was offered a fellowship in plastics at Mellon Institute sponsored by the Plaskon Co. After two years at Mellon, Doctor Bigelow was transferred to the main plant of the Plaskon Co. in Toledo where his present duties consist in correlating research, sales, and production problems. Doctor Bigelow is a member of A.S.T.M. Committee D-20 on Plastics and is a consulting member of Subcommittee II of Committee D-9 on Electrical Insulating Materials. He is also a member of the American Chemical Society, Illuminating Engineering Society, and American Institute of Chemists.

J. H. Foote, Supervising Engineer, The Commonwealth & Southern Corp., Jackson, Mich., received his B.S. in Civil Engineering from Michigan State College and was then engaged in maintenance work and later in field survey and foundation drilling in connection with hydro-electric projects. Following this a number of years were spent in distribution and transmission line engineering and construction for electricity supply companies. He then was engaged in electrical station and substation design and supervision for electric companies of the Commonwealth Power Corp. system. Since 1936 he has been in charge of the engineering organization which designs steam and electric stations, lines, office and service buildings, etc., for constituent companies of The Commonwealth & Southern Corp. He serves on several A.S.T.M. committees, including B-1 on Copper and Copper-Alloy Wires for Electrical Conductors (chairman since 1938), A-5 on Corrosion of Iron and Steel, and E-5 on Standing Committees. He is a Fellow of the American Institute of Electrical Engineers, a member of the Engineering Society of Detroit, Michigan Engineering Society, Society for the Promotion of Engineering Education, and the National Vocational Guidance Association.

Alexander Foster, Jr., Vice-President, Warner Co., Philadelphia, Pa., received his early education in the Philadelphia public schools, and was graduated from the University of Pennsylvania in 1908 with the degree of B.S. in C.E. In 1912 he obtained his C.E. degree. In 1908, Mr. Foster was engaged in road and property surveys in South Jersey, with the Surveyor of Cape May County. From 1909 to 1921 he was with Wm. Steele and Sons Co., Philadelphia, specializing in plain and reinforced concrete design and construction, and from 1919 to 1927 he served as President of West Jersey Sand and Supply Corp. Mr. Foster started a central-mix concrete plant in Philadelphia in 1921. In 1927 he became identified with the Warner Co. as Vice-President, and since 1931 he has also been President of King Farms Co. and King Supply Co. Mr. Foster has been an active member of the A.S.T.M. Philadelphia District Committee, and is also a member of the American Society of Civil Engineers, American Concrete Institute, Philadelphia Engineers Club, and the Union League of Philadelphia.

Lawford H. Fry, Railway Engineer, Edgewater Steel Co., Pittsburgh, Pa., was born in Richmond, Province of Quebec, Canada, and obtained his technical training at the City and Guilds of London (England) Technical Institute, the University of Göttingen, and the Hannoversche Technische Hochschule. He was in the shops and office of the Baldwin Locomotive Works, 1897 to 1899; Sales Engineer, 1904; and Engineer of Tests, 1905. He then became European Technical Representative of the company. Returning to this country in 1913, he became head of the Metallurgical Department, Standard Steel Works, Burnham, Pa., and remained there as Metallurgical Engineer until 1930. In that year he became Railway Engineer, Edgewater Steel Co. Mr. Fry has been very active in the work of A.S.T.M. Committee A-1 on Steel, serving on a number of its subcommittees, and is now chairman of Subcommittee XIII on Methods of Physical Tests. He serves on Committees E-1 on Methods of Testing and E-8 on Nomenclature and Definitions He is a member of the American Society of Mechanical Engineers, and at the 1938 annual meeting of this Society was awarded the Worcester Reed Warner Medal for "written contributions relating to improved locomotive design and utilization of better materials in railway equipment." Mr. Fry is also a member of the following English societies: the Institute of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Locomotive Engineers. He is the author of a book, "A Study of the Locomotive Boiler," and has contributed a large number of articles on locomotives and on metallurgical subjects to the technical press of this country and of England.

Annual Meeting Jottings

One of the interesting items at the meeting was the cry "There's a convoy going by" and many of our members and guests saw not too far off in the ocean their first convoy, escorted by blimps and probably other antimine and submarine protection. It brought home as nothing else probably could the nearness of the conflict. Oil on the beach might also have been a very unpleasant reminder, but fortunately the beach was clean and the bathing good.

We have had many favorable comments on Doctor Lundell's Presidential Address covering "Chemical Requirements and Chemical Analysis." It is a splendid address and every member should read it. Doctor Lundell presented it in abstract form. Members who want a copy of the complete address can get one by writing to the Society. It of course will appear in the *Proceedings* when published during the winter. A by-product of the address is the paper in this issue by one of Doctor Lundell's associates dealing with a matter of vital concern to many members and more than one past-president—the measurement of fish.

The gentleman who fainted during the President's Address recovered very quickly and was around for meetings the next day. Many members asked how he was. Incidentally, the secretary of a brother association tells us that this was the third general session of a meeting where he had noted someone passing out. Our only comment will be that after the hectic week of meetings and sessions some of our members go through it is only fair to excuse them if they do adopt this method of obtaining surcease for a time.

The local restaurants and stores had signs, "Welcome American Testing Materials Convention," which while somewhat of a misnomer is not as bad as the one in the restaurant across from Society Headquarters which during the annual meeting of the American Society for Metals last fall welcomed "the American Society of Metal Delegates."

Responsible for what may be good and definitely for what is bad in the ASTM Bulletin, we were somewhat taken back when Doctor Gauger, in accepting for himself and Professor Todd the A.S.T.M. Dudley Medal, said he could hardly wait to get the box open and see what kind of medal was really being given to him this year, since he had noted in the ASTM Bulletin an announcement of the "Award of the A.S.T.M. Dudley Metal." Sure enough, in the May issue's Provisional Program, we changed the award as indicated, but the two worthy winners of the Medal this year can rest assured that they are getting good quality—the same as previous winners have had. There is no ersatz here as yet.

One of our active members, and incidentally, a college chum, was quite embarrassed to get off his train coming from the north scheduled for Florida, to find that he had someone else's bag. The series of events demonstrated railroad efficiency—his bag was delivered two days later—we don't know how far South it had gone. In the meantime, he had the privilege of buying a new suit in Atlantic City (at his expense). College professors will be absent-minded—as well as the rest of us!

For many of our members who are faculty members or otherwise concerned with the important work of the Society for the Promotion of Engineering Education, it was a very gracious move for the S.P.E.E. to have its meetings in New York begin on June 28. This question of scheduling meetings with a minimum of conflicts is one that haunts society officers and secretaries.

One of our past-presidents sitting in the back row of a meeting session was surprised to have one of the speakers whose paper had not been preprinted refer to the "work of our committees since the Third Century B.C." Some of them go back pretty far and probably a number have been accused of still using archaic methods, although we must defend them to the end. Regardless, the word used happened to be pretty close to what our past-president had heard—instead of "our committees" it was "Archimedes." We will take responsibility for this one and go to the foot of the class.

Recognition of Forty-Year Members

Beginning with the 1938 Annual Meeting of the Society, one of the interesting features has been the recognition of forty-year members, through the presentation of a suitably engrossed certificate to those individuals or companies which have been continuously affiliated with the Society over a period of four decades.

This year at the annual meeting 15 members were recognized, nine individuals and six companies as follows:

Charles Derleth, Jr.	Bradley Stoughton
W. C. DuComb	J. L. Van Ornum
W. R. Edwards	The Ajax Metal Co.
J. E. Greiner	International Harvester Co.
N. F. Harriman	Jones & Laughlin Steel Co.
W. M. Saunders	Lukens Steel Co.
H. E. Smith	Sherwin-Williams Co.
	Standard Steel Works Co.

The certificates were presented by T. G. Delbridge, presiding officer, at the general session on Wednesday evening.

W. A. Selvig, U. S. Bureau of Mines; H. C. Porter, Chemical Engineer. Mr. and Mrs. L. H. Winkler, Bethlehem Steel Co., Inc. G. O. Hiers and C. H. Hack, National Lead Co. T. A. Wright, Lucius Pitkin, Inc.; H. V. Churchill, Aluminum Company of America; in the background, M. L. Fuller, The New Jersey Zinc Co.; and, barely discernible, C. C. Nitchie, Bausch & Lomb Optical Co. Mr. and Mrs. L. W. A. Meyer, Tennessee Eastman Corp.; G. M. Kline, National Bureau of Standards

Philadelphia District Plans Meetings—One on Timber, Sept. 24

SEVERAL MEETINGS are planned during the fall and spring under the auspices of the Philadelphia District Committee headed by F. G. Tatnall, Baldwin-Southwark Corp. The first—on September 24—is to be held in the Lecture Hall of Franklin Institute with one of the country's outstanding authorities in the field of timber scheduled as the chief speaker, L. J. Markwardt, Chief, Division of Timber Mechanics, U. S. Forest Products Laboratory, Madison, Wis. Because of the increasing use of timber in construction and various other applications, where previously other materials have been used, and also the remarkable development of the forms in which the wood can be supplied as plywoods, veneer, and so forth, many members and others in the Philadelphia District will be interested in this meeting.

The very extent of the literature in the more or less specialized fields of engineering materials makes it difficult to keep abreast of new developments and to appraise their significance. It is the purpose of Mr. Markwardt's talk to highlight some of the more important developments in timber construction and use, and to review the significant research accomplishments on this material. The talk will be illustrated with lantern slides and exhibits.

Included in the presentation will be the following:

Recent research results on the microscopic structure of wood; chemical seasoning, which provides a revolutionary method of drying wood; developments in glues as they open new horizons in wood construction; the technique of plywood, affording versatility in properties and application; modification of wood properties, through resin impregnation (impreg wood); resin impregnation and compression (compreg wood) affording in effect a new material; improvements in joints and fastenings by means of modern metal connectors; the development of laminated construction, and the laminated arch; principles of structural grading; and progress in housing research.

Mr. Markwardt is a graduate of the University of Wisconsin in Civil Engineering, receiving a B.S. Degree in 1912 and the C.E. Degree in 1922. He served three years on the faculty of the Engineering College of the University of Wisconsin, and is co-author of a book on Descriptive Geometry. He has been in engineering research work at the U. S. Forest Products Laboratory at Madison for nearly 30 years. At the Laboratory he is in charge of the Division of Timber Mechanics, which now is carrying on extensive research on war problems.

Mr. Markwardt is the author of numerous bulletins, papers, and articles dealing with the properties and engineering uses of wood. He is a member of the American Society for Testing Materials, the Society of American Foresters, and the Engineering Society of Wisconsin. Also, he is a member of the Timber Research Committee of the International Union of Forest Research Organizations and attended international conferences in this field at London in 1937 and 1939.

On October 2, A.S.T.M. will join with the American Society for Metals in a session of definite interest to all metallurgists and those concerned with the field of aircraft in which leading aviation people will explain what they have found in certain foreign type planes and engines which have come into our possession. This meeting is scheduled for Temple University.

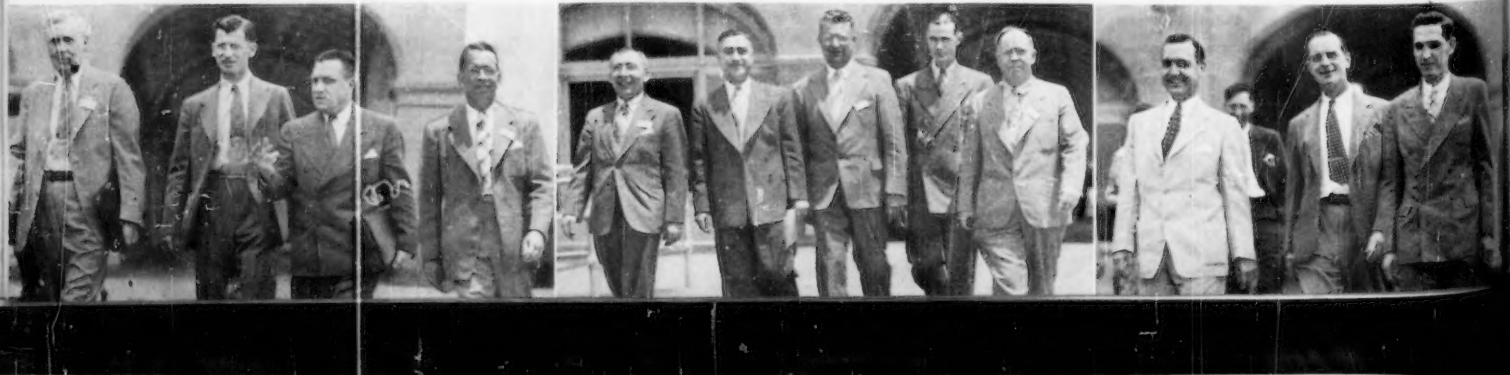
In January, probably at the time of the January meetings of Committee A-1 on Steel, Norman L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric and Manufacturing Co., will speak on the subject, "Theory of Specifications and Their Application," embodying in his discussion some of the very widespread experiences he has had in purchasing and using a wide range of materials. This meeting will be held at Franklin Institute.

On February 10 there will be held a session on plastics at which two outstanding men will talk, Dr. Allan A. Bates, Director, Research Laboratories, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., and Dr. M. H. Bigelow, Director of Technical Service, Plaskon Co., Inc., Toledo, Ohio. Dr. Bigelow is a new member of the A.S.T.M. Executive Committee.

The final meeting, scheduled for March 31, is on the subject of building materials featuring problems in masonry construction, use of brick, and related matters. There have been many developments in this field and Judson Vogdes, Engineer, Day & Zimmerman, Inc., who is in charge of the meeting will have a panel of experts assigned to cover various topics of general interest.

All A.S.T.M. members and others who are interested are cordially invited to attend these meetings.

P. V. Tippet, Farrel-Birmingham Co.; Lewis Probst, Pennsylvania Forge Co.; J. A. Succop, Heppenstall Co.; J. D. Tyson, Standard Steel Works Div., Baldwin Locomotive Works. Martin Fleischmann, Timken Steel and Tube Div., Timken Roller Bearing Co.; A. H. Salerno, J. F. Wyzalek, J. L. Cannon, all with the Hyatt Bearings Div., General Motors Corp.; H. C. Weirick, Steel and Tube Div., Timken Roller Bearing Co. A. O. Schaefer, The Midvale Co.; F. H. Pennell, De Laval Steam Turbine Co.; C. W. Johnson, National Forge and Ordnance Co.; R. S. Saunders, Lynn Works, General Electric Co.



A Scanning Electron Microscope[1]

V. K. Zworykin,[2] J. Hillier,[2] and R. L. Snyder[2]

An image, no matter how produced, may be regarded as subdivided into individual image elements, each of which bears a certain definite relationship to an elementary area of a similarly subdivided object. If the geometrical arrangement of the corresponding elements in image and objects is similar and if there is a regular relationship between certain characteristics of the image elements, for example, brightness or color, and the same or other characteristics of the object elements, such as transparency, reflectivity, or mass density, the image is regarded as faithful.

The formation of an image may result either from the simultaneous imaging of all the elements, as in the projection of a picture on a screen, a photographic plate, or the retina of the human eye by optical lenses, or by the successive recording of individual image elements, a process familiar today from the practice of television.

Modern high-power electron microscopes may utilize either of these procedures, the different interactions of the several object elements with the incident electron beam producing the intensity variations observed in the image. The conventional electron microscope, like any ordinary optical instrument, records the whole array of elements simultaneously in the form of an electron-optical image. The scanning microscope, on the other hand, adopts the methods of television, that is, records one picture element at a time, as the result of the scanning of the object by a beam with a cross-section of the order of an object element in area.

Each type of electron microscope has its own particular sphere of usefulness; the conventional electron microscope is primarily suited for the study of "transparent" objects, specimens less than 1 μ in thickness, while the scanning microscope has as its special province the investigation of the surface of opaque (to electrons) objects. On the one hand, the adaptation of the conventional instrument to the direct observation of surfaces brings about a great loss in resolution (*1*)[3] or excessive distortion of the image (*2*), or both; satisfactory results are obtained only by preparing a surface replica and observing this in place of the original specimen (*3*). On the other hand, the employment of the scanning principle for the observation of transparent objects, as realized in a construction of von Ardenne (*4*), results in an instrument more complex in operation than the conventional electron microscope without material compensating advantages. Roughly, the two types correspond to the biological and the metallurgical microscope, respectively, of light optics.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Presented at the Forty-fifth Annual Meeting, Am. Soc. Testing Mats., Atlantic City, N. J., June 22–26, 1942.

[2] Associate Director, and Research Engineers, respectively, Research Laboratories, R.C.A. Manufacturing Co., Camden, N. J.

[3] The italic numbers in parentheses refer to the reports and papers appearing in the list of references appended to this paper.

The Development of the Scanning Microscope in the R.C.A. Laboratories

The "Electric" Microscope:

The interest of the R.C.A. Laboratories in the scanning microscope is an outgrowth of a preoccupation with the development of electronic television. Thus the first application of the scanning principle to microscopy (*5*) consisted in combining a television pickup camera and receiving system with an ordinary light microscope with quartz optics (Fig. 1). This arrangement permitted the direct viewing on the kinescope of the magnified images of specimens illuminated with ultraviolet or infrared light by utilizing the ultraviolet and infrared sensitivity of the photosensitive mosaic in the iconoscope or television pickup tube. The magnified ultraviolet or infrared image is projected on the mosaic and forms a charge image thereon —a distribution of charge everywhere proportional to the distribution of intensity of radiation in the original image. The scanning beam of the iconoscope releases the charge in the individual picture elements in succession, generating a signal which ultimately controls the brightness of the scanning spot on the kinescope screen, the latter being synchronized with the spot on the iconoscope mosaic. Thus the charge image, and hence the ultraviolet or infrared image, is reproduced visibly on the kinescope screen.

In the above arrangement the imaging of the original specimen is carried out in the conventional manner, with-

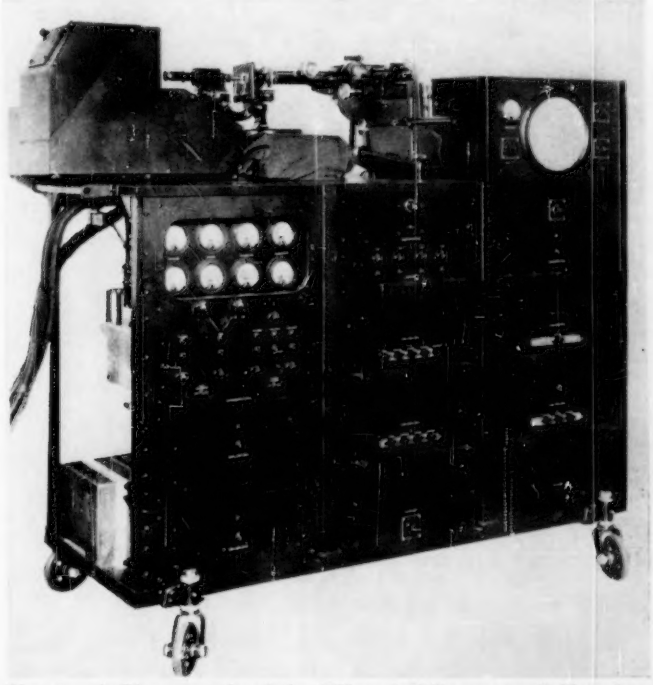


Fig. 1.—A Photograph of the "Electric Microscope" Showing the Ultraviolet Light Optical Microscope with Its Associated Illuminating Equipment, the Iconoscope Housing, the Amplifiers, and the Kinescope.

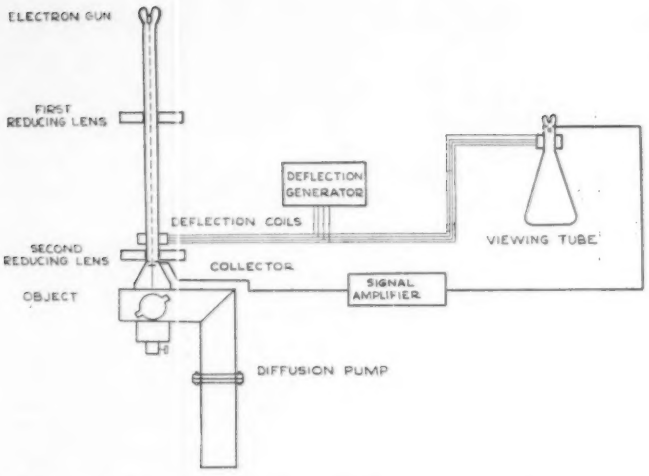


Fig. 2.—A Schematic Diagram of an Early Scanning Microscope.

out invoking the scanning process. Thus the "electric microscope" is not a true scanning microscope. However during this development it was realized that supplemental magnification (*5*) could be obtained electronically by simply reducing the size of the area scanned on the iconoscope mosaic while keeping the size of the viewed picture the same. It must, of course, be pointed out that the magnification so obtained does not reveal any new information beyond that obtainable with the optical system used. If, instead of scanning a charge image of the specimen as produced in the iconoscope, the specimen itself is scanned by an extremely minute beam and the secondary emission is used to actuate the kinescope, we have the fundamentals of a scanning microscope.

The Monoscope as a Scanning Microscope:

The first actual demonstration of a true scanning microscope resulted when a monoscope (*6*), that is, an iconoscope with the mosaic replaced by a half-tone screen, used for testing the transmission properties of a television channel, was inserted in place of the iconoscope and the deflection amplitude of the monoscope beam was reduced to a very low value. Since, at all times, the total area scanned on the kinescope screen corresponds to the total area scanned on the screen of the pickup tube (monoscope), the picture observed on the viewing screen then represents a greatly magnified image of the scanned portion of the half-tone screen, the scale of magnification being given by the ratio of the linear dimensions of the two scanned areas.

Two essential changes were required to pass from the monoscope to a practical scanning microscope. On the one hand it was necessary to make provision for exchanging specimens; on the other, the size of the scanning spot had to be reduced to a very small value, since the diameter of the spot is equal to the least separation of two points of the object which can be resolved in the final image.

Direct-Viewing Scanning Microscope:

An early scanning microscope, constructed with these two principles in mind, is represented schematically in Fig. 2. Electrons from the cathode are accelerated into the first anode at a potential of about 400 v and form a narrow "crossover" in the plane of a 0.020-in. aperture. This aperture is imaged on the object by the two-stage reducing system consisting of two magnetic electron lenses, each by itself producing a reduction in the spot size by a factor approximately equal to 30. The object is maintained at a voltage of 800 v., as in this region a relatively large variation in the secondary emission of the surface with the character of the latter is to be expected. The object is surrounded by a collector electrode at a somewhat higher potential (approximately 850 v.). The secondary electron current collected by this electrode produces a voltage drop across a signal impedance which is amplified by a regular television video amplifier and eventually applied to the control grid of the viewing tube.

The scanning of the object is accomplished with the aid of the magnetic deflection yoke situated just above the second reducing lens, the beam describing a scanning pattern of 441 lines on a total area of the object 0.005 to 0.010 in. in diameter once every thirtieth of a second.

The relatively simple instrument described above, normally operated with a magnification between 1000 and 2000, was capable of attaining a resolution of about 1 μ. While this was gratifying as a beginning, it was not in any sense comparable in performance with the conventional electron microscope, and even falls short by almost an order of magnitude of the resolving power of the metallographic light microscope. Nevertheless, the resolution of 1 μ obtained probably came close to the optimum that could be expected with an instrument using an oxide-coated cathode and providing a directly viewed 441-line television image. With a still smaller scanning spot, as required for an improvement in resolution, the beam current, and hence the signal currents, would have become so small that the intensity variations of the image would have been lost in random fluctuations of brightness, that is, in picture noise.

Noise, Beam Current, and Resolution:

Picture noise is due, primarily, to the thermal noise of the input resistor, giving rise to fluctuations V_n in the voltage impressed on it, their root-mean-square value being

$$\overline{V_n}^2 = 4kTRF$$

where

k = Boltzmann's constant (1.37×10^{-16} erg per deg. Cent.),
T = the absolute temperature of the resistor,
R = its resistance, and
F = the frequency band transmitted by the amplifier.

This must be compared with the signal voltage

$$V_s = i_s R$$

where i_s is the current from the collector. The signal-to-noise ratio hence becomes

$$S = V_s/(\overline{V_n}^2)^{1/2} = R^{1/2} i_s/(4kTF)^{1/2} = 0.78 \times 10^{10} i_s (R/F)^{1/2} \quad \ldots\ldots (1)$$

The band width F is fixed by the requirement that the full information contained in the picture signal is transmitted by the amplifier to the viewing tube. The transmission of a picture of 260,000 ($441 \times 441 \times 4/3$) picture elements repeated 30 times per second requires a frequency band of at least 4 megacycles per second (*7*). The effec-

tive signal resistance, R, on the other hand possesses an upper limit of the same order as the shunted impedance of the capacitances of the collector electrode and the grid of the input tube of the amplifier at the highest frequency transmitted. If this capacitance is of the order of 15 $\mu\mu$f, it may be shown that R cannot be greater than about 7000 ohms (*8*). Thus, in the case considered here,

$$S = 3.3 \times 10^8 i_s \quad \text{.....(1a)}$$

i being measured in amperes.

The maximum value of the beam current i_b striking the object, and hence of the signal current i_s, may be deduced from elementary optical consideration. In any optical system the apparent brightness of an image is at best equal to the brightness of the object multiplied by the squares of the indices of refraction at the image and the object. Here brightness may be defined as amount of radiation (or charge) emitted per second per unit area of the image and object into unit solid angle. The index of refraction, on the other hand, is given by the velocity of the electrons. Since the source obeys Lambert's law, its "brightness" is j_o/π, where j_o is the thermionic emission per unit area. The "brightness" of the image spot, scanning, is $i/(\pi A\theta^2)$, where i is the total current in the scanning beam, θ, its angle of convergence, and A, the area of the spot. Accordingly the maximum beam current is given by

$$i = A\theta^2 \cdot (V/V_o) \cdot j_o \quad \text{.....(2)}$$

where V_o, mean volt-velocity of the electrons leaving the hot cathode, is of the order of 0.1 v., while V represents the potential of the object relative to the cathode.

The magnitude of θ is determined by the resolution required. Let the least distance which is to be resolved—in other words the diameter of the scanning spot—be equal to d. As in the case of the conventional microscope, this quantity is determined primarily by the spherical aberration of the final lens:

$$d_{\text{spher.}} = C \cdot f \cdot \theta^3 \quad \text{.....(3)}$$

where C is a dimensionless constant characteristic of the lens and f is the focal length of the lens, and, for very small values of θ, by diffraction at the aperture of the same lens:

$$d_{\text{diffr.}} = \lambda/\theta \quad \text{.....(4)}$$

Here λ, the wave length of the electrons, is given by $1.228 \times 10^{-7}/V^{1/2}$ cm.

Consider first the case of the scanning microscope discussed above, having relatively low resolution. Here it is adequate to put $d = d_{\text{spher.}}$ Substituting θ from Eq. 3 in Eq. 2 and recalling that $A = \pi d^2/4$,

$$i = \pi(d^{8/3}/(8Cf)^{2/3} \cdot (V/V_o) \cdot j_o \quad \text{.....(5)}$$

If the secondary emission ratio of the object is near unity, it will normally be necessary to require a signal-to-noise ratio equal to 10, so that parts of the object differing in secondary emission by 10 per cent can still be distinguished. Hence, from Eq. 1a, a required beam current of $3.0 \cdot 10^{-8}$ amp. may be assumed. Putting furthermore

Cf = 10 cm.,
V = 800 v.,
V_o = 0.1 v.,
j_o = 1 amp. per sq. cm.

Equation 5 may be solved for d, leading to a least resolvable separation

$$d = 1.0 \times 10^{-4} \text{ cm.} = 1.0\,\mu$$

This is, in fact, the resolution observed with the instrument in question. The fact that the limit was reached must be ascribed to the unusually great secondary emission contrast of the specimen observed.

Next, it is of interest to inquire how small the beam current must be in order to achieve the optimum resolution obtainable for the given voltage and aperture defect coefficient Cf. This optimum resolution is obtained if θ is given the value which minimizes $d = d_{\text{spher.}} + d_{\text{diffr.}}$, that is, if

$$\theta = (\lambda/(3Cf))^{1/4} \quad \text{.....(6)}$$

$d = (4/3)\lambda^{3/4} \cdot (3Cf)^{1/4} = 1.7 \times 10^{-6}$ cm. or 170 Å. for V = 800 v. and Cf = 10 cm., and, by Eq. 2,

$$i = \pi(4/9)\lambda^2(V/V_o) \cdot j_o = 2.1 \times 10^{-14} j_o/V_o = 21 \times 10^{-14} j_o \quad \text{.....(7)}$$

This beam current is independent of the voltage of the specimen. Substituting this in Eq. 1a, the signal-to-noise ratio becomes 7×10^{-5}.

Three methods may be applied to improve the signal-to-noise ratio in the image, making the attainment of high resolutions possible. The current density at the electron source may be increased; the noise introduced by the amplifier may be reduced, for example, by utilizing an electron multiplier; and, finally, the frequency band may be reduced by replacing the viewing tube by a relatively slowly recording device, such as a facsimile receiver.

The first step in this direction consisted in replacing the thermionic cathode in the scanning microscope by a cold cathode, in the form of an appropriately etched and rounded single crystal tungsten point (*9*, *10*). Three sealed-off microscope tubes without the magnetic lenses used to focus the spot on the specimen are shown in Fig. 3. The point cathode is sealed in on the wide end, the specimen on the narrow end of the tube. With points of this type and an applied voltage of a few thousand volts it is possible to obtain current densities of some ten thousand amperes per square centimeter originating from areas a fraction of a micron in diameter.

In view of the very small size of the source—which is imaged directly on the specimen—a single stage of reduction is quite adequate. With such tubes it was occasionally possible to view satisfactory images of the specimen magnified 8000 times directly on the screen of the viewing tube. At the same time the extreme sensitivity of the tungsten points to gas residues in the tube, causing frequent shifts in the emitting points even in carefully baked sealed-off tubes, makes their use in demountable systems impractical. Accordingly it was decided to return to a thermionic cathode of high specific emission and to rely for the necessary improvement in the signal-to-noise ratio primarily on a reduction of the frequency band by slowing up the rate of recording of the image and on a diminution of the amplifier noise by the introduction of an electron multiplier.

In the new scanning microscope a regular facsimile recorder (*11*) was thus employed in place of a kinescope viewing tube. This recorder prints a 750-line image $7^1/_2$

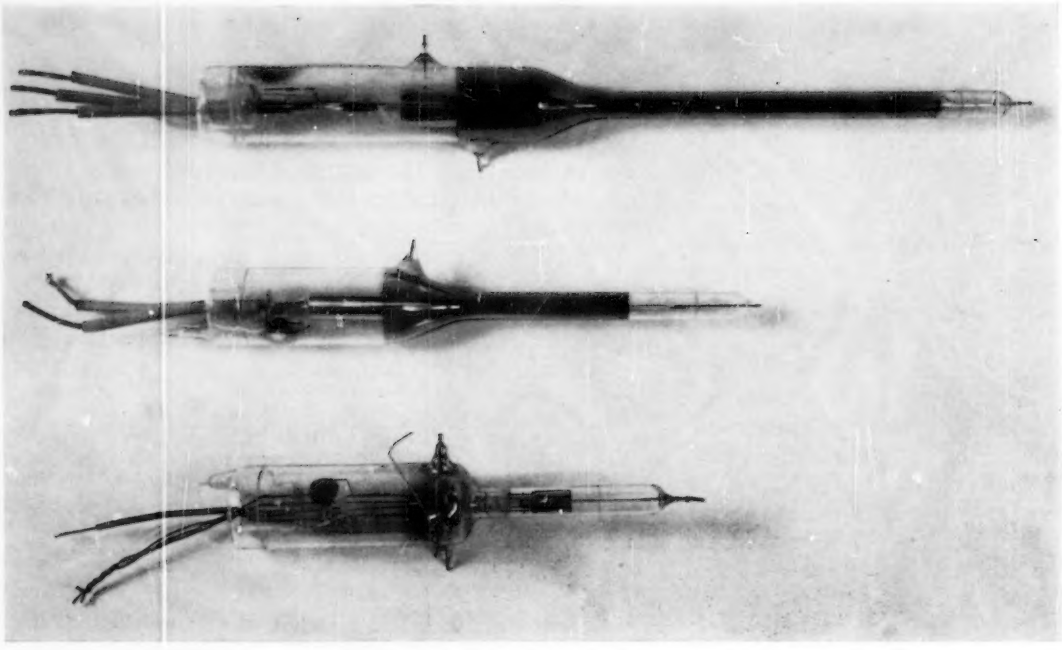


Fig. 3.—Three Sealed-Off Scanning Microscope Tubes Using Cold Cathodes.

The tungsten points from which electrons are obtained by field emission are hidden by cylindrical anodes situated near the middle of the tubes. The specimens are mounted on the wires which pass through the right-hand end of the tubes.

by 6 in. in size every 10 min. Since the scanning time is increased by a factor $8 \times 60 \times 30 = 14{,}000$ as compared with the previously used television transmission system, the pass band of the amplifier may be reduced by this same factor, that is, to about 300 cycles, if the same number of picture elements is to appear on the facsimile image as before on the kinescope screen. Actually the pass band was made 700 cycles, approximately doubling the possible resolution along the scanning lines of the image. The frequency pass band being thus reduced by a factor of 6000, the signal-to-noise ratio was, according to Eq. 1, improved by a factor 78.

The remaining improvement in the signal-to-noise ratio came about as the result of the employment of a selected electron multiplier (R.C.A. 931) (*12*, *13*) as a preamplifier for the secondary-emission currents from the specimen. With an applied over-all voltage of 1250 v. the gain of this tube is approximately 1 million, while the output "dark current" i_d was found to be only about 0.5 microampere. For extremely small signal currents it is the shot noise of this dark current which determines the noise in the image, the fluctuations in the signal being given by (*14*)

$$\overline{i}^2 = 2i_dF/G \qquad (8)$$

so that the signal-to-noise ratio now becomes

$$S = G^{1/2}i_s/(2ei_dF)^{1/2} \qquad (9)$$

where G is the gain of the multiplier. With $G = 10^6$, $e = 1.60 \times 10^{-19}$ coulombs, $i_d = 0.5 \times 10^{-6}$ amp., and $F = 700$ sec.$^{-1}$,

$$S = i_s \times 10^{+14} \qquad (9a)$$

Inserting the maximum beam current consistent with optimum resolution (Eq. 7):

$$i_s = 21 \times 10^{-14} \quad j_o = 21 \times 10^{-14} \text{ amp.}$$

assuming again that the current density at the cathode is 1 amp. per sq. cm. (which is probably too low by an order of magnitude), and

$$S = 21$$

This signal-to-noise ratio, obtainable under ideal conditions, is large enough to justify the expectation that a scanning microscope utilizing an efficient electron multiplier and a facsimile recorder can yield images with a resolution close to the optimum obtainable in view of electron diffraction phenomena and of the spherical aberration of the lenses of the microscope, with signal-to-noise ratios of 10 or better—the least ratio which will give a satisfactory image.

Scanning Microscopes Incorporating an Electron Multiplier, Facsimile Recorder, and Mechanical Scanning:

Figure 4 is a schematic diagram of the first scanning microscope installation incorporating both improvements.

The electron source, at the bottom of the microscope, consists of a thin tungsten wire fed by a regulated radio-frequency power supply. It may be oriented with respect to a two-element electrostatic lens comprising the grid and the anode of the electron gun by means of three micrometer screws. A 3000-cycle square voltage wave is applied to the grid so as to give the beam, and hence the signal current, a 3000-cycle modulation. In addition to this, a variable direct-current grid bias is provided to regulate the current in the beam.

The anode, as well as the remainder of the channel through which the beam passes, with the exception of the center electrodes of the two reducing lenses and the specimen itself, is normally maintained at a potential of 10,000 v. with respect to the cathode, the voltage supply being stabilized to within 0.001 per cent by negative feedback.

After traversing two masking apertures, the beam passes through the first electrostatic reducing lens, which forms an image of the crossover of the beam, the reduction factor being of the order of 50. It may be adjusted by varying the potential of the center electrode with respect to the cathode, a stabilized 2000-v. supply being provided for this purpose. About halfway between the first and second lens, at the end of a narrow tube acting as electrostatic

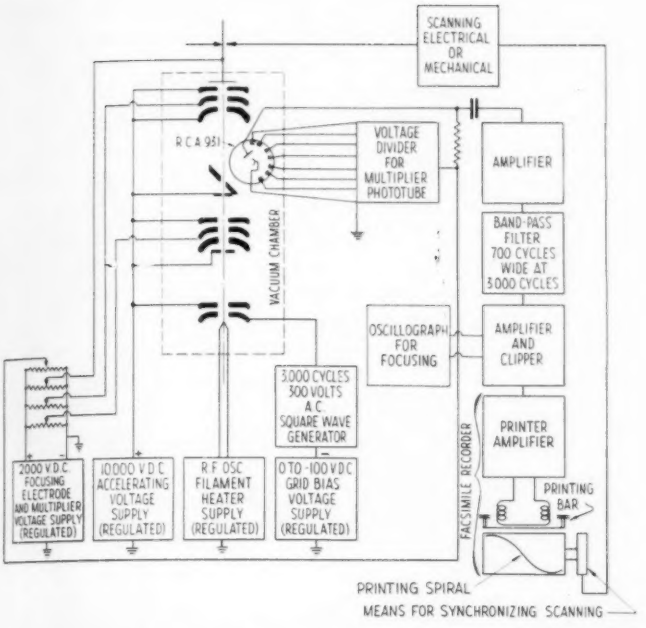

SCANNING ELECTRICAL OR MECHANICAL
R C A 931
VOLTAGE DIVIDER FOR MULTIPLIER PHOTOTUBE
AMPLIFIER
BAND-PASS FILTER 700 CYCLES WIDE AT 3000 CYCLES
VACUUM CHAMBER
OSCILLOGRAPH FOR FOCUSING
AMPLIFIER AND CLIPPER
3000 CYCLES 300 VOLTS A.C. SQUARE WAVE GENERATOR
PRINTER AMPLIFIER
FACSIMILE RECORDER
PRINTING BAR
2000 V.D.C. FOCUSING ELECTRODE AND MULTIPLIER VOLTAGE SUPPLY (REGULATED)
10000 V.D.C. ACCELERATING VOLTAGE SUPPLY (REGULATED)
R.F. OSC. FILAMENT HEATER SUPPLY (REGULATED)
0 TO -100 V.D.C. GRID BIAS VOLTAGE SUPPLY (REGULATED)
PRINTING SPIRAL
MEANS FOR SYNCHRONIZING SCANNING

Fig. 4.—Schematic Diagram of a Complete Scanning Microscope Installation in Which the Signal Is Detected by a Secondary Emission Multiplier and Recorded by Means of a Facsimile Printer.

shield for the beam, is another aperture of the final lens. It is placed approximately at the center of an inclined fluorescent screen. The final lens, similar in construction to the first lens, forms the scanning spot, imaged on the specimen. The latter may be translated in three directions in the same manner as the source.

The construction of one of the lenses is shown in Fig. 5. They are made of Kovar metal, the roughly machined collars for the three electrodes being sealed together with glass in a high-frequency furnace. Finally the threads are cut on a lathe on the complete unit and the electrodes proper are screwed into them. This assures the perfect alignment required for satisfactory operation.

On striking the surface of the specimen, the primary electrons eject secondary electrons. These have low initial velocities, corresponding to accelerating voltages of 0 and 10 v. The strong accelerating field between the specimen and the uppermost electrode of the final lens draws them back through the final lens, which focuses them at some point between it and the inclined fluorescent screen. Due to the smaller initial velocity of the secondary electrons, the lens action of this lens is much stronger for the secondary electrons than for the electrons of the original beam. The secondary electrons, diverging from

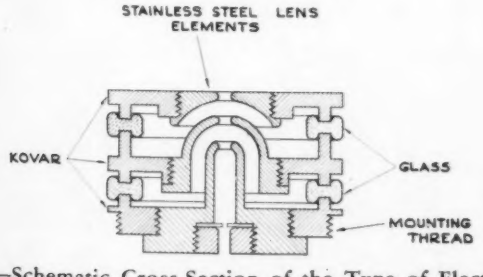


Fig. 5.—Schematic Cross-Section of the Type of Electrostatic Lens Used in the Scanning Microscope.

their point of focus, form too wide a beam to pass through the fine aperture in the fluorescent screen. They fall on the screen instead and their energy is, to a considerable extent, converted into the bluish light characteristic of the luminescent substance employed. A large fraction of this light falls on the photocathode of the electron multiplier placed into a favorable position relative to the screen and gives rise to a photo-current which, suitably amplified and filtered, forms the signal current controlling the printer bar of the facsimile recorder.

The advantages of using a complete, sealed-off electron multiplier in the microscope are obvious: it eliminates the danger of contamination of the sensitive surfaces when air is admitted into the microscope and makes an exchange of multipliers an easy matter. Maximum efficiency is attained in this system by matching the peak of sensitivity of the photocathode of the multiplier and the peak of the emission characteristic of the fluorescent material (Fig. 6).

The scanning in this microscope was mechanical, the object being displaced in two mutually perpendicular directions by rods mounted on loudspeaker voice coils. The two rods were coupled to a vertical shaft bearing the specimen at its lower end. The shaft was suspended in a diaphragm a short distance above the object, so that the displacement of the object was approximately $^1/_{10}$ that of the voice coils.

Two spiral cams mounted on the facsimile recorder and rotating with line frequency and picture frequency, respectively, controlled the displacement of the voice coils and hence that of the specimen in the two directions. The circumference of each cam moved across a slit placed between a light source fed by a stabilized power supply and a photocell, the linearly varying current from the latter

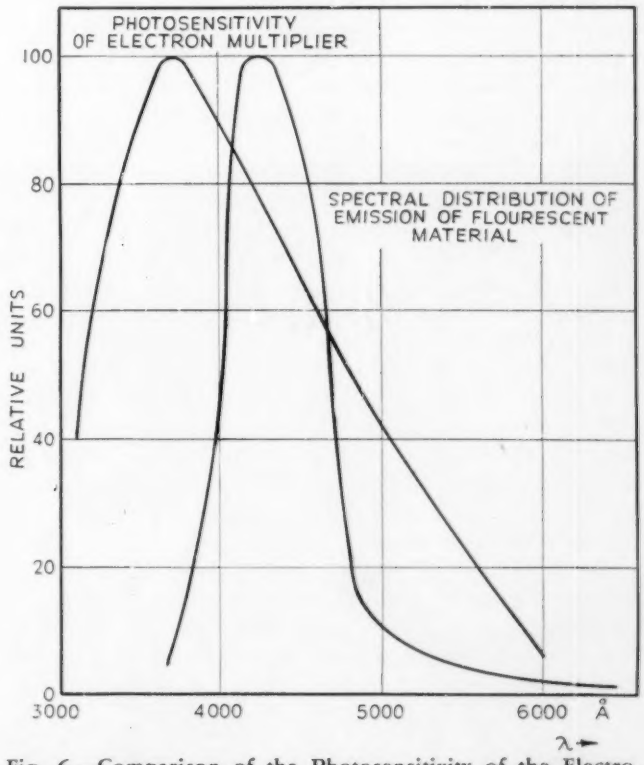


Fig. 6.—Comparison of the Photosensitivity of the Electron Multiplier and the Spectral Distribution of Emission of the Fluorescent Materials Used in the Scanning Microscope.

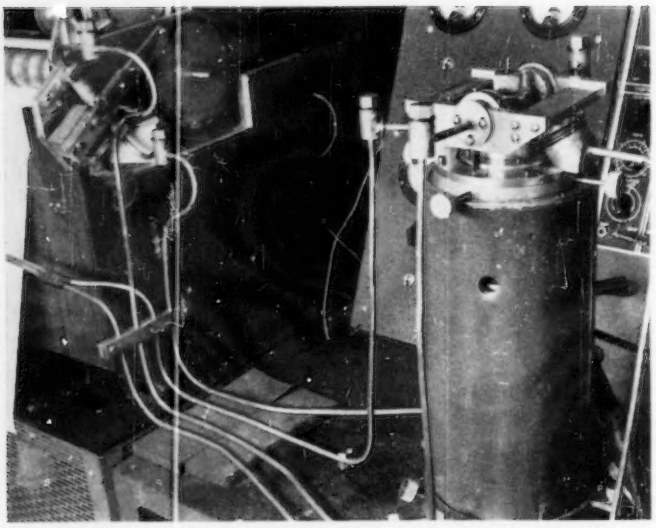


Fig. 7.—The Scanning Microscope Equipped with a Hydraulic Scanning System.

The driving cam and the associated lever and bellows can be seen in the upper left mounted on the facsimile printer while the two-directional specimen scanning mechanism can be seen mounted on the upper end of the microscope column on the right.

being supplied, after amplification, to the windings of the voice coils.

In addition to the adjustments for the electron source and the specimen, two sets of four screws are provided for displacing the upper half of the microscope horizontally and for rocking it with the fine aperture in the fluorescent screen as a center of rotation, these serving to obtain proper alignment of the lenses and apertures. Vacuum joints are made tight with neoprene gaskets. Glass and hard-rubber rings serve to insulate parts of the microscope which are at different potentials from each other. The whole instrument is surrounded by a triple permalloy shield to eliminate the effect of external magnetic fields. The evacuation is accomplished by an oil-diffusion pump backed by a rotary oil pump. It was expected that the increase in the scanning time would correspondingly increase the difficulty of aligning and focusing the instrument. However, by incorporating a standard cathode-ray oscillograph in the electrical circuits in such a way that the image signal may be viewed continuously, it has been found possible to focus and align the instrument quickly and accurately by using the magnitude and high-frequency content of the output signal as the criterion for adjustment.

The greatest difficulty experienced with this instrument arose from the extreme sensitivity of the object to mechanical vibration. Consequently, the specimen head was redesigned, introducing extreme damping and replacing the voice coils by oil-filled bellows, whose expansion and contraction were controlled hydraulically by the two cams on the facsimile recorder. Figure 7 shows the hydraulic system installed on the instrument. Figure 8 shows an example of the pictures obtained with the scanning microscope at this stage. The resolution of this picture is approximately 500 Å, signifying a decided step in advance of the metallographic light microscope.

The Scanning Microscope with Magnetic Deflection; Results:

The only remaining drawback in the instrument with hydraulic scanning consisted of insufficient uniformity in the rate of translation of the specimen resulting from the imperfect construction of the cam surfaces. Hence, in the final design mechanical scanning was abandoned altogether and replaced by magnetic scanning.[4] This required a number of modifications, which are shown schematically in Fig. 9. Up to the second image of the effective source of the electrons, the ray path is unchanged. However, this second image, in place of being formed directly on the specimen, is imaged once more by a third electrostatic lens of approximately unity magnification on the stationary specimen, the path of the rays passing through an aperture in an inclined fluorescent screen. A baffle at cathode potential—or even negative with respect to the cathode—is placed in front of the specimen so as to reduce the electrostatic field at the object surface, causing the returning beam of secondary electrons to spread out

[4] While the beam deflection method of scanning was recognized as having many advantages, it could not be incorporated in the original design because of the double use of the final lens and because of the small clearance space available between the specimen and the final lens.

Fig. 8.—A Scanning Electron Micrograph Produced with the System Shown in Fig. 7. A Deeply Etched Nickel Surface (× 800).

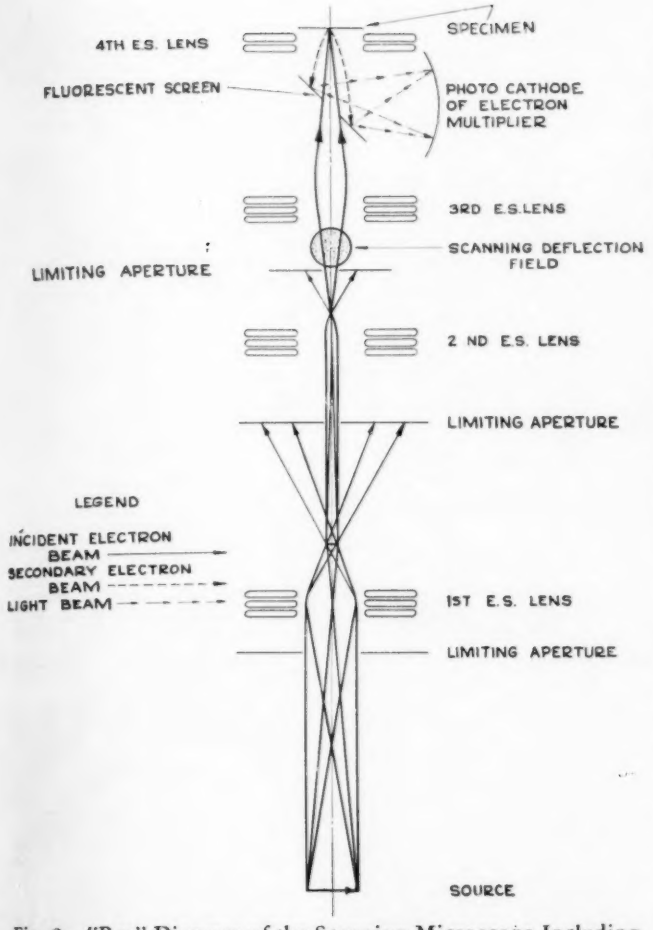


Fig. 9.—"Ray" Diagram of the Scanning Microscope Including the Most Recent Modifications.

and to impinge on a larger area of the fluorescent screen. Together with the edge of the cylinder at anode potential, which provides an electrostatic shield for the beam, the baffle forms a fourth electrostatic lens. The light from the fluorescent screen again is used to generate the photo-current in an electron multiplier, which, in turn, after amplification, controls the motion of the printer bar in the facsimile recorder.

The magnetic scanning is accomplished by a small deflection yoke consisting of two pairs of coils wound on a styrol form which is placed just below the third lens. The deflection currents are controlled by the approximately linear change in potential obtained by charging a condenser through a resistance and amplified by a stabilized d. c. amplifier. Synchronization with the horizontal motion in the recorder is assured by a commutator contact, discharging the line-displacement condenser at the end of each line. The discharging of the vertical displacement condenser is accomplished manually by pushing a button.

It is seen that the role of the third lens is twofold; first, to make possible the location of the deflecting field close enough to the center of the lens to prevent a material enlargement in the scanning spot at the maximum deflection due to the utilization of the outer portions of the lens and yet far enough from the object to have a small effect on the paths of the secondary electrons; second, to provide space for the luminescent screen and the electrode reducing the field at the surface of the specimen.

Figure 10 shows the complete apparatus. It is to be noted that the multiplier is here located outside the microscope, the light from the fluorescent screen reaching its photo-cathode through a large-aperture lens. This signifies a further simplification of construction.

Figures 11, 12, and 13 show pictures obtained with the scanning microscope in its present form. The resolution of these pictures may be estimated to lie near 500 Å. Even though this is as yet some distance from the optimum to be expected with scanning microscopes employing electron lenses of known types, it goes sufficiently far beyond the performance of the metallurgical light microscope to render it a valuable tool in researches primarily concerned with the observation of surfaces. To gain an idea of the range of application of the scanning microscope, it is merely necessary to consider the many fields in which the metallographic and toolmakers' microscope have become indispensable aids. First among these are the study and surveillance of the effects of hardening and finishing processes of machine parts and bearings. Surface structure beyond the resolution of the light microscope has a vital influence on resistance to corrosion and mechanical wear, as well as the flow resistance and heat transfer of surfaces. Examining the interior of the parts, as metallographic sections, the effects of different methods of processing on the strength and ductility of the material may be checked by observing the resultant etching structure, which, as with certain spheroidized iron carbide steels, is often too fine to be recognized by conventional methods. To these must be added the study of nonmetallic glazes and finishes, of the surfaces of cathodes and anodes,

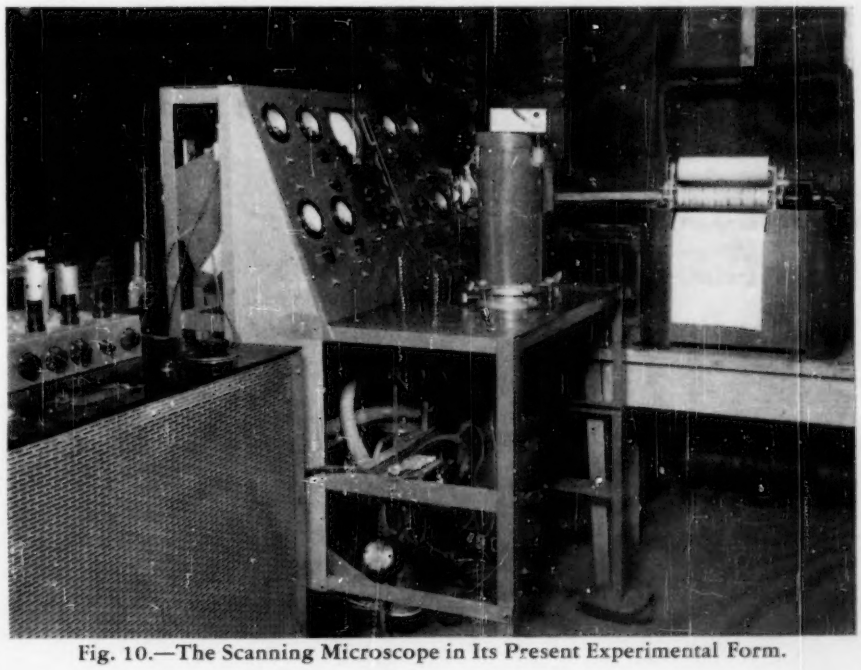


Fig. 10.—The Scanning Microscope in Its Present Experimental Form.

Fig. 11.—A Scanning Electron Micrograph of the Surface of Nickel Which Had Been Polished with Fine Carborundum (× 2600).

and of the exact form of parts required for special techniques, for example, extremely fine apertures. Beyond this there stretches out the broad field of surface structures of plant and animal tissues and other biological applications.

It is apparent from the above description that the development of this type of electron microscope has been dependent on concurrent developments in many associated fields. The last described instrument for instance includes the most recent techniques of television, facsimile, secondary emission multipliers, fluorescent material, and electron microscopy.

Summary

The scanning electron microscope represents an application of the techniques of electronic television and electric picture transmission to the formation of highly magnified images of arbitrary objects. The scanning process translates some property, such as the electron transparency or the secondary emission sensitivity, varying over the area of the object, into a signal current which is utilized to resynthesize a magnified image on the viewing tube or recorder. Its special province is the imaging of object surfaces.

The principal problems encountered in the design of an electron scanning microscope are concerned with resolution and intensity. It is relatively simple to obtain, with the aid of two stages of reduction, a spot size which does not exceed the optimum resolution obtainable with the scanning microscope in view of diffraction phenomena and the spherical aberration of the lenses, these playing substantially the same role as in the conventional electron microscope. On the other hand the current in such an "electron probe" is so small that, with ordinary thermionic amplifiers, the picture detail would be completely lost in the noise, or random fluctuations of intensity, in the image—particularly if the latter recorded sufficiently rapidly to be observed continuously on a television viewing tube.

A first attempt to overcome this difficulty by making use of the much higher current densities obtainable with

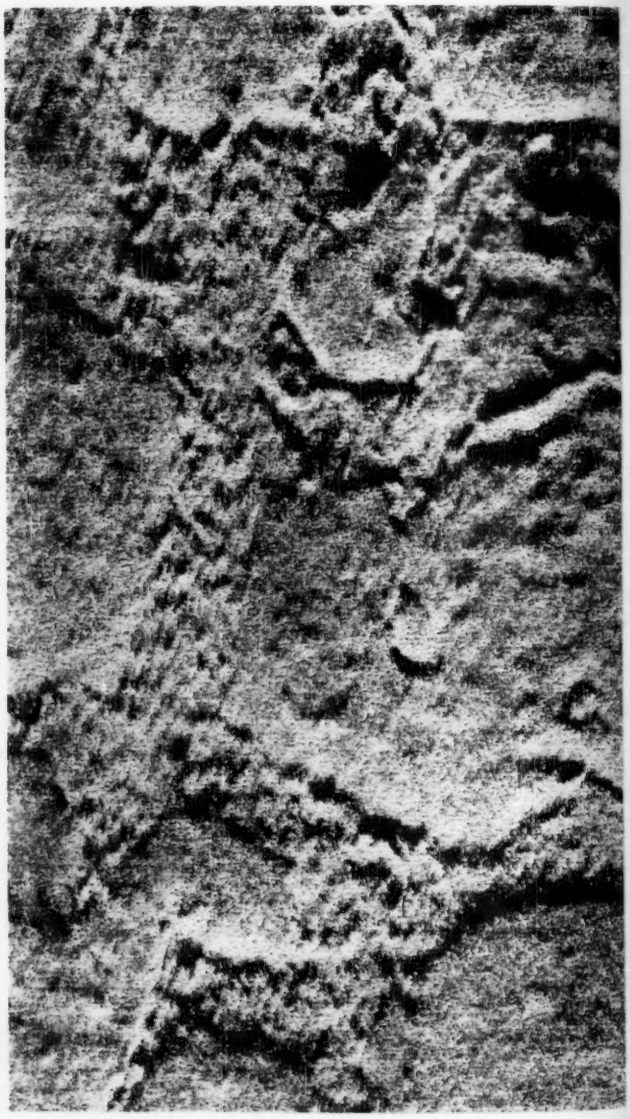


Fig. 12.—A Scanning Electron Micrograph of the Surface of Slightly Annealed Brass.

The specimen was polished and etched with nital (× 5000).

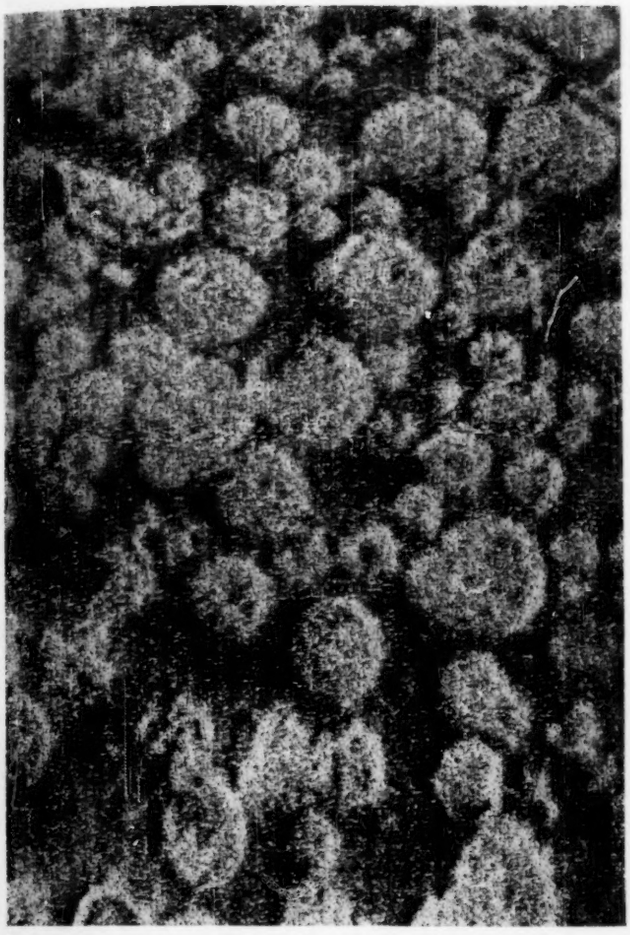


Fig. 13.—A Scanning Electron Micrograph of the Surface of a Ground and Etched Surface of Bakelite Containing Carbonyl Iron Particles (× 3000).

field emission cathodes yielded promising results, but was abandoned in view of the unsteadiness of cathodes of this type. Reliance was placed instead on greatly diminishing the speed of recording by replacing the viewing tube by a facsimile recorder, forming a picture in 8 min., and in utilizing an electron multiplier as preamplifier, which practically eliminates the noise introduced by the coupling resistance. Instead of letting the secondary electrons ejected by the specimen as the result of the scanning with the electron probe fall directly on the first stage of the multiplier, they are permitted to fall on a luminescent screen, whose light emission is concentrated on the photocathode of a sealed-off multiplier. In this manner a gain in signal is obtained in addition to a simplification in the operation of the instrument.

In the first realization of this scanning microscope the scanning was mechanical, the specimen being displaced by loudspeaker voice coils synchronized with the motion of the facsimile recorder. As this arrangement proved too sensitive to mechanical vibration, it was replaced, first, by a hydraulic linkage between the object and the recorder and, finally, by a system of magnetic scanning. A few of the pictures taken with this instrument, showing resolutions of the order of 500 Å, are reproduced.

Acknowledgments:

The development described was carried on for a period extending over several years, and by a large number of the workers in this laboratory. We wish to mention in particular the early work of A. W. Vance and L. E. Flory. The authors also wish to thank E. G. Ramberg for aiding in the preparation of this manuscript and for his valuable assistance in connection with the mathematical problems involved in the design of these instruments.

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(7) V. K. Zworykin and G. A. Morton, "Television," Section 6.8, John Wiley and Sons, New York, N. Y. (1940).

(8) Reference (7), Section 14.18, p. 435.

(9) C. F. Eyring, S. S. Makeown, and R. A. Millikan, "Field Currents from Points," *Physical Review*, Vol. 31, pp. 900–909 (1928).

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(12) J. A. Rajchman and R. L. Snyder, "An Electrically Focused Multiplier Phototube," *Electronics*, December, 1940.

(13) R. B. Janes and A. M. Glover, "Recent Developments in Phototubes," *RCA Review*, Vol. 6, July, 1941, pp. 43–54.

(14) V. K. Zworykin and G. A. Morton, reference (7), p. 13.

Water Handbook Published

A NEW HANDBOOK on Industrial and Municipal Water, which is arranged in two sections—"Water Analyses" and "Interpretations"—has been issued by W. H. & L. D. Betz, Gillingham and Worth Sts., Frankford, Philadelphia, Pa. Twenty-five different methods of water analyses are discussed, with procedures and calculations. Such water analyses as hardness, alkalinity, phosphate, sulfite, turbidity, oil, calcium, specific conductance, etc., are covered. With but one exception, all of these tests are indicated as simple accurate determinations requiring little or no previous chemical background. Bacteriological analyses are not included.

The second section of the book is devoted to interpretations of the tests and their application to plant control. Included here are discussion of such subjects as carbonate and non-carbonate hardness, pH control, steam purity, inter-crystalline cracking, corrosion, and many others.

A number of charts and illustrations increase the utility of this new publication and it should be of definite interest to power plant engineers, executives, operating engineers, and plant chemists and others interested in water. In a spiral binding, $8\frac{1}{2}$ by 11-in. page size, this 64-page book can be obtained at 50 cents per copy.

The Measurement of Length[1]

DEDICATION.—This note was withdrawn from storage and dedicated to retiring President Lundell on the evening of June 24, 1942, after he had practically asked for it by remarking, in the course of his address, that measuring the length of a fish was so simple that almost any one could do it.

(Preferably read aloud)

APPARENTLY IT is not generally known that it is possible to devise systems of measuring length, differing radically from the customary one, which consists essentially in counting the number of times a unit length, such as one foot, must be applied to cover the length to be measured.

Another system which has attained some popularity is that for which the name "physhtorie system" has been coined. In this system lengths are measured from a fixed point, such as the zero of a scale. The numbers assigned to the points on the scale are such that the measured lengths are proportional to the weights of geometrically similar objects of equal density, such as fishes.

To make a scale of this kind it is necessary to start with a unit length, which is called a sthorie or occasionally a physhtorie. The size of the unit depends upon the species of both fish and fisherman, but in any particular case, there is a unit. A special verb is also needed for the act of measurement, for just as a sailor never measures depth, but "takes soundings," so when lengths are measured in sthories, the verb used is "to toll."

For example, in a case where the unit is 5 in. long, this length would be 1 sthorie, 10 in. would be marked 8 sthories, 15 in. would be marked 27 sthories, etc., while 11 in. correspond approximately to 11 sthories. Thus while lengths tolled in physhtories are proportional to the weights of geometrically similar fishes, they are also proportional to the ordinary lengths the fishes would have after being drawn[2] through a standard die, or after being extruded into sausages of uniform diameter. When such a scale is used, one sthorie is tolled for a 5-in. fish, but 27 sthories are tolled for a 15-in. specimen and 64 sthories for a 20-in. one.

In cases where there is a legal lower limit to the length of fish that may be taken, this length automatically becomes one sthorie and the scale is not graduated below one sthorie since such fractional sthories are considered unduly risky, and the one by whom they are tolled may find himself fined or even confined.

It would be entirely possible, and not at all illogical, to use such a system for all length measurements, but for most purposes, the system would be at a disadvantage because lengths would not be additive in the usual way. Thus 1 sthorie and 8 sthories, lying end to end, would extend as far as 27 true sthories, a property highly inconvenient in the building trades, for example, though it might be useful for special purposes. This property is no disadvantage when fishes are to be tolled, since they rarely lie in this particular way.

Another disadvantage of the physhtorie system for ordinary purposes is that the unit is subject to secular changes. It has been observed that in the course of time, the unit shrinks, so that the numbers representing lengths become larger. Although no theoretical basis for this secular change is known, no exception has ever been observed, and it has come to be accepted as a universal law of nature that the length of a particular fish, when tolled in physhtories, always increases with the passing years.

The system is, however, an entirely possible one because it has the necessary property of preserving what has been called the absolute significance of relative magnitude, which plays an important part in dimensional analysis. No matter what unit may be used for the sthorie a 14-in. fish, tolled in sthories, will always be 8 times as long, and a 21-in. specimen 27 times as long as a 7-in. specimen. While it is true that the ratio of two lengths has an absolute significance, in any one system, because it is independent of the size of the unit used, comparison of the physhtorie and ordinary systems shows that the absoluteness is merely relative, since the ratio is not the same in the two systems.

In their own way, lengths in the physhtorie system are also additive. For example, the sum of the lengths, tolled in sthories, of all of the fish in a catch will be equal to the length of a single equivalent fish. If the unit is so chosen that the length of a fish weighing 1 lb. is 1 sthorie, the sum of the lengths will also be equal to the weight, in pounds, of the catch, provided the fishes are geometrically similar.

The physhtorie system based on the third power, is applied only to fishes that can be tolled. Higher powers may be used for those that got away. Systems based on powers higher than the third are unofficial.

Speaking seriously, the physhtorie system is less absurd, and is better adapted to its special purpose, than many systems of measurement in use, such as the various designations of size of thread in the textile industry, of wire in

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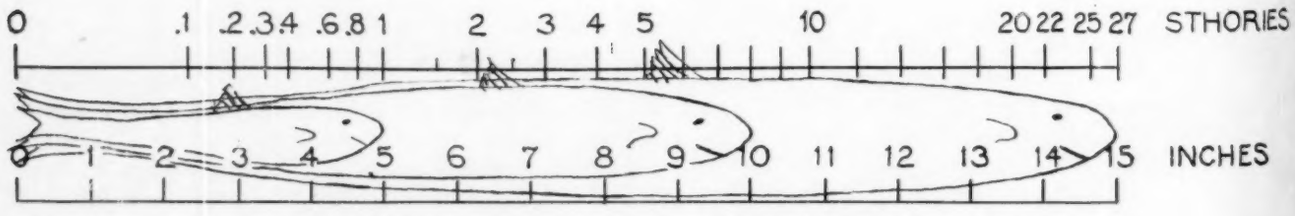
NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Submitted by an A.S.T.M. Member.

[2] This is probably the meaning of the familiar gesture which accompanies fisherman's narratives.



Physhtorie and inch scales. 5 inches = 1 sthorie. Magnification × 0.3937

the metal working industries, and of density in the petroleum and other beverage industries, using "beverage" as meaning any rare and precious fluid.

Although only one illustration has been given, it is evident that an infinite number of systems of length measurement can be devised. Some of these, like the one described, may be better adapted to special needs, than the ordinary system.

The physhtorie system has not received the recognition it deserves because of lack of adequate standards. In order to realize the full possibilities of the system, standardized unit sthories for each kind of fish must be established, eliminating the fisherman as an independent variable. Thus there would be trout sthories, bass sthories, salmon sthories, tuna sthories, sailfish sthories, swordfish sthories, catfish sthories, and inevitably sucker sthories. It might even be necessary to establish a different unit sthorie for the same kind of fish in different localities. Thus a trout which might have extended to over a hundred sthories in Maryland, might have extended to less than a dozen in Alaska.

This is the kind of standardizing work that obviously belongs to the A.S.T.M. which could later refer its work to the American Standards Association for approval as an American standard. Several existing committees have designations which might entitle them to claim the assignment, such as B-8,[3] which would, however, not be suitable because it deals entirely with superficial, rather than fundamental, matters. C-8 has a good claim, as the indicated magnification is about that required, but although fish are admittedly refractory, and their heat treatment is of great importance, these characteristics are not the important ones in the proposed standardization. It would therefore be best to assign the work to a new committee, I-8, in which the Bureau of Fisheries should be well represented. Having gotten as far as I, there may later be a K-9 committee also.

When the Society has included the standards in its book of Standards, a fisherman who reports taking a trout that tolled 17 physhtories, will not be regarded as a candidate for membership in the largest and least exclusive club in all the world, but as an accurate observer, who reports facts ascertained by reference to recognized standards.

[3] A "mispronouncing glossary" is appended to this paper.

A MISPRONOUNCING GLOSSARY (DIAGRAM)

B-8; Beight = Bait
C-8; see 8
I-8; I ate
K-9; canine
lying; lieing
physhtorie; fish story
risky; risqué
sthorie; story
tolled; told.

Cotton Fiber-Length Determination Using the Fibrograph[1]

By K. L. Hertel[2]

SYNOPSIS

The fibrograph is an optical instrument employing photovoltaic cells for scanning samples of parallel fibers and simultaneously tracing a length-frequency curve. The geometrical properties of the resulting curve, or fibrogram, make it possible quickly to obtain average lengths of various kinds, variance, coefficients of variation, and other statistical measurements. The time for a complete length analysis is 6 to 7 min. The waviness and taper of the fibers are factors that make the fibers appear too short. The upper-half mean length, however, agrees closely with the staple length. Fibers shorter than 1/4 in. are disregarded.

THE IMPORTANCE of fiber length and of length uniformity is well recognized by all cotton technologists. The plant breeder, as well as others, needs instrumentation that gives these properties quickly, accurately, and as objectively as possible. Since the problem was approached from the standpoint of the breeder, the first instrument was designed to analyze seed cotton. Soon it became obvious that both time and labor could be saved by analyzing properly composited lint samples. Methods for preparing such samples were

Fig. 1.—Fibrograph.

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[1] Paper presented before a meeting of the Raw Cotton Subcommittee, Committee D-13, on Textile Materials, American Society for Testing Materials, at Providence, R. I., March 11, 1942.

[2] Head, Department of Physics, University of Tennessee, Knoxville, Tenn.

studied both mathematically and experimentally, with the result that many additional advantages were obtained by using the lint-sample analysis.

Realization of the obvious advantages of representing fiber lengths by a curve resulted in the design of a photoelectric instrument (Fig. 1) that scans the fiber sample and traces a type of length-frequency distribution curve. It is obvious that the amount of light passing through the fibers into the scanning slit depends, among other factors, upon the number of fibers in front of the slit; hence, the instrument can continuously record the number of fibers as a function of the position of the slit along the sample. When the fiber ends in the sample are evened up, as in a seed sample, the resulting recorded curve is readily seen to be equivalent to the familiar cumulated length-frequency distribution curve. The difficulties of realigning the fiber ends, once they have been removed from the seed, prompted a theoretical study of the curve that obtains when the fiber ends fall at random. The details of this study have been published,[3] and only the more important conclusions will be pointed out here. Since the information concerning length usually desired by the cotton technologist is readily obtained from the random sample curve, every effort is made to produce that curve as accurately as possible.

Sample

In the theoretical treatment of the problem, the fibers were assumed to be uniform except for length, which is only approximate. In the development of the theory, the random sample was obtained by selecting a fiber at random from a large population, using sharp-pointed tweezers. The fibers were arranged perpendicular to a base line, with the point of selection on the line and the tweezers oriented the same way each time. Because of symmetry, there is the same amount of fiber and the same distribution of lengths on either side of the base line. Henceforth, the portions of the fibers on one side of the base line will be considered the random sample. Although the fibers are not arranged in order of the partial length extending beyond the base line, they could be rearranged with the longest portion at one side and the shortest at the other. If the rearranged partial lengths then were equally spaced, the tips of the fibers would fall on the curve that is traced by the fibrograph. It is this curve that has such convenient geometrical properties.

The sample prepared with the tweezers has the desired characteristics, but its preparation would be tedious and slow. Instead of selecting one fiber at a time, two combs each with 200 steel needles for teeth serve to select the fibers in the desired random fashion as the fibers on each comb are combed by the other comb. Any lack of randomness that exists when the fibers are first placed on the combs soon disappears as the fibers are transferred from one comb to the other. In a short time, a trash-filled nonuniform group of fibers is combed to a uniform sample with the trash lodged back of the teeth and out of the sample. Randomness seems to be aided by carefree and relaxed manipulation rather than by the systematic or strained action of the conscientious beginner. There is some bias, since the very short partial lengths are too abundant, making the curves unreliable in the region of fibers shorter than about 1/4 in. The analysis, therefore, disregards the short fiber that is usually negligible.

[3] K. L. Hertel, "A Method of Fibre-Length Analysis Using the Fibrograph," *Textile Research*, Vol. X, No. 12, October, 1940, pp. 510–525.

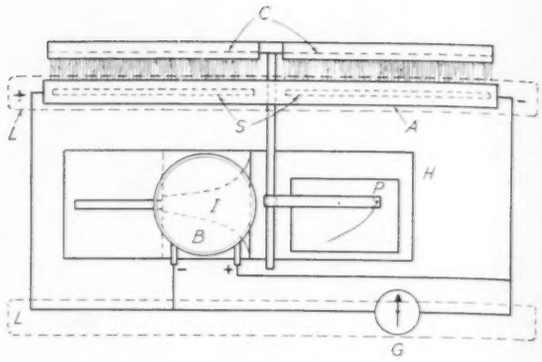

Fig. 2.—Diagram of Fibrograph.

Fibrograph

The fibrograph (Fig. 1) is an optical instrument for converting optical density into relative number of fibers, and tracing a curve of the number of fibers as a function of position. The essential parts of the instrument are shown diagrammatically in Fig. 2. The light from a tubular incandescent lamp, *L*, passes through the scanning slit, *S*, to the analyzing photovoltaic cell unit, *A*. The light from both tubular lamps, *L*, also illuminates a screen and the reflected light passes through the iris, *I*, to the balancing photovoltaic cell, *B*. When the system is balanced, the illumination on *B* produces exactly the same current in *B* as is produced in *A* by the light that passes through the cotton and falls on *A*. No current, therefore, passes through the galvanometer, *G*, as is indicated by its zero deflection. As the cotton sample, *C*, attached to the pen, *P*, is moved, the light on *A* changes. The card holder, *H*, attached to the iris, *I*, is moved simultaneously to produce the same current in *B* and, hence, to keep the galvanometer from deflecting. If the iris has the proper shape the curve traced by the pen, *P*, on the moving card represents the relative number of fibers at each position along the sample. When the cotton has all been scanned there is no change in the light on *A* and the curve becomes vertical. The pen is released to trace the vertical axis of zero cotton and then *H* is

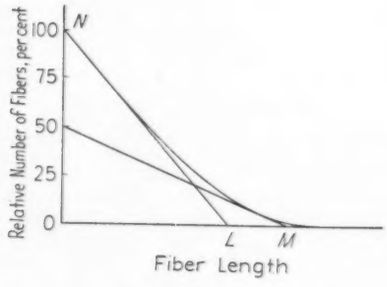

Fig. 3.—Fibrogram with Tangents.

returned to trace the axis of zero length, completing the curve which is called the fibrogram.

Fibrogram

The fibrogram obtained from such a sample does not resemble either the length-frequency or the cumulated length-frequency curve. It does, however, bear the same relation to the cumulated length-frequency curve as the cumulated length-frequency curve bears to the original length-frequency curve. It might be considered a doubly cumulated length-frequency curve or the second integral of the length-frequency curve. Because of the mathematical relationship, it has some interesting properties, and because the random character of the sample is so similar to the random character of the fibers in all textile products, these properties seem to have important physical significance. For instance, the average length of the fibers in the original population is given by the intercept on the length axis of a tangent drawn to the fibrogram at the short-fiber end. Some of these properties are shown in Fig. 3. The tangent *NL* gives the mean length *OL* of the fibers in the original population. The tangent through the 50 per cent point intercepts the mean length *OM* of the longer half by weight of the fibers and has been called the upper-half mean length. The linearity of the fibrogram is a measure of the length uniformity of the fibers. The area between the tangent *NL* and the fibrogram is proportional to the variance, and the ratio of area *LMN* to area *LNO* is the coefficient of variation squared. The ratio of *OL* to *OM* is also a function of the linearity of the fibrogram and has been called the length-uniformity index. It is much easier to obtain than the ratio of the areas and is quite well correlated with the coefficient of variation. The length-uniformity index is an empirical relation and should be distinguished from the other quantities that have theoretical and geometrical significance.

Results

The fibrograph records the data in the form of a curve or fibrogram from which several measurements may be obtained. Ordinarily the proper tangents are drawn to intercept the mean length and the upper-half mean length which are recorded. Since there is no magnification along the length axis, measurements are made directly and in any units desired. The upper-half mean length is approximately the same as the staple length, although there is no reason to believe that the classer attempts to measure the identical length that the fibrograph measures. The data in Table I are taken from a variety test made by N. I. Hancock and analyzed using the fibrograph and by the classer.

TABLE I.—FIBER LENGTH OF LINT SAMPLES FROM VARIETIES IN THE TEST AT JACKSON, TENNESSEE, 1938.

Variety	Fibrograph Upper-Half Mean Length in 1/32 in.	Classer Staple Length in 1/32 in.
Acala 44–5	33.6	32.8
Clevewilt	34.2	34.4
Cokers 100	36.2	35.0
Deltapine 10	32.9	33.4
Deltapine 11A	34.4	33.8
Rowden 4046	32.1	31.6
Stoneville 2A	33.9	33.8
Stoneville 2B	35.9	35.4
Trice W2-1-2	30.2	31.0
Washington	35.6	35.0
Grand mean	33.9	33.6

Pope and Ware[4] have made extensive comparisons and reported the standard deviation of a single determination of the upper-half mean length to be 0.57 of 1/32 in. or 0.018 in.

The fibrograph does not give the absolute fiber length, for several reasons. One of the important reasons is the waviness of the fiber in the sample, and the other is the tapering of the fiber ends. To test the relation between the absolute lengths and those given by the fibrograph, three cottons were carefully sampled and more than 3000 fibers from each measured by the laborious projection method[3] and using the fibrograph. Table II shows the results. On the average, the fibrograph length multiplied by a factor of 1.19 gives the absolute lengths of the fibers. It should be noted that the factor is about the same for the three cottons.

The time for a complete analysis, consisting of drawing the sample, combing it, tracing the fibrogram, drawing the tangents, and measuring the two intercepts is 6 to 7 min.

Conclusions

Cotton fiber length analysis using the fibrograph is rapid and yet is about as accurate as any instrumental method. Results are given in the form of a curve that has a number of important geometrical properties expediting the measurement of various average lengths, percentages of various length intervals, variance, and coefficient of variation. The upper-half mean is about the same as the staple length.

Waviness and tapering of fibers cause an apparent shortening of the absolute length, which is approximately the same for the several cottons tested. In upland cottons, fibers shorter than 1/4 in. are disregarded.

[4] O. A. Pope and J. O. Ware, "Influence of Variety, Season, and Location on the Fiber Properties of Cotton," presented at the meeting of the American Society of Agronomy, New Orleans, La., November 22–24, 1939.

TABLE II.—SAMPLES OF COTTON.

Method of Measurement	7/8 in. Upland		1 3/16 in. Upland		Sea Island	
	Mean Length in 1/32 in.	Upper-Half Mean Length in 1/32 in.	Mean Length in 1/32 in.	Upper-Half Mean Length in 1/32 in.	Mean Length in 1/32 in.	Upper-Half Mean Length in 1/32 in.
Projection	26.6	32.9	33.2	43.9	44.5	61.8
Fibrograph	22.3	27.4	28.4	36.6	37.4	51.8
Ratio	1.19	1.20	1.17	1.20	1.19	1.19

A. C. Fieldner Receives High Honor

THE INSTITUTE of Fuel of England will award the Melchett Medal for outstanding achievement in work involving scientific preparation and use of fuel to Dr. A. C. Fieldner, A.S.T.M. past-president and Chief of the Technologic Branch, and also of the Coal Division, U. S. Bureau of Mines. He will be the second American honored with this medal which was first awarded in 1930. An outstanding authority in the field of fuels, Doctor Fieldner has for over 35 years taken a leading part in the work of the Bureau of Mines. In 1919 he was made supervising chemist at the Bureau of Mines and later was appointed Superintendent of the Bureau's Central Experiment Stations Division. Successively he became Chief Chemist, Chief Engineer of the Experiment Stations Division in Washington and since 1936 has been in his present positions. During the first world war Doctor Fieldner was in charge of gas mask investigations and served with the Chemical Warfare Service directing the Gas Mask Research Division.

Internationally known as the inventor and developer of many techniques of testing and analyzing coal, coke, and gas, he is recognized as having contributed to science a comprehensive knowledge of the properties and values of coal and related fuels.

Doctor Fieldner has been active in A.S.T.M. work for many years and has served as chairman of Committee D-5 on Coal and Coke since 1920. He was president of the Society 1936–1937. He is also active in many other professional and scientific organizations.

As Chief of the Technologic Branch of the Bureau of Mines, Doctor Fieldner now directs such diversified activities as petroleum investigation, exploration for strategic minerals, metallurgical research on the ores of vital war metals, and research work in the testing of coal, all of which currently is devoted to the successful prosecution of the war.

Cooperative Research Council on Fuels and Lubricants

THE AMERICAN Petroleum Institute and the Society of Automotive Engineers having organized the Cooperative Research Council to direct cooperative research in the development of the best combinations of fuels, lubricants, and equipment powered by internal combustion engines, thus providing a means for combining under one head research work which has heretofore been conducted separately by the two organizations or jointly through the Cooperative Fuel Research Committee. It has been mutually agreed that the Cooperative Research Council, rather than the Society of Automotive Engineers, will provide the Secretariat for the Cooperative Fuel Research Committee, the CFR Fuels Advisory Committee, and the S.A.E. Lubricants Advisory Committee, the latter two, having been combined, to be known as the CRC War Advisory Committee.

Mr. C. B. Veal who has been very active for a number of years in this work is secretary of the Council with offices at 30 Rockefeller Plaza, New York, N. Y.

List of Prohibited Items for Construction Work

AS OF JUNE 29, 1942, the Army and Navy Munitions Board issued a memorandum to various Army and Navy Departments covering a list of prohibited items for construction work, which applies to all construction work, including accessory site improvement, under the cognizance of the War and Navy Departments, but the list is not applicable to construction equipment or ship construction. Since this list has been made applicable to all public and private construction in a "Directive" of May 20 by Donald M. Nelson, it is of widespread interest. The provisions of this list are more restrictive than those in the one dated April 1, and amendments are mandatory for projects rated on and after July 6.

The communication indicated that if the use of any item or material prohibited by this list is deemed essential in a construction project, the Army and Navy Board will authorize the use of such an item or material if the facts in the case justify exception. The list is too extensive to permit publication here, but copies can be obtained by contacting the Army and Navy Munitions Board, Washington, D. C.

A few examples from the list may indicate its general content:

Aluminum:	And its products of all kinds are prohibited with the exception of foil used in electrical equipment.
Copper:	And its alloys including brass and bronze are prohibited for use in products of all kinds except some seventeen uses which are listed. Following this, numerous specific uses where copper and its alloys are prohibited are listed.
Spruce:	Lumber and veneer (aircraft grade only) and products made therefrom are prohibited.
Tin:	And its products of all kinds are prohibited except as follows: Babbit metal where necessary, coatings, fuses and fuse plugs, solder, not over 30 per cent, and sprinkler head fuses, etc., etc., etc.

1942 Municipal Year Book

RECEIVED RECENTLY from the International City Managers' Association, 1313 East Sixtieth St., Chicago, Ill., is the voluminous 1942 Municipal Year Book which gives a résumé of activities and statistical data of American cities as edited by Clarence E. Ridley and Orin F. Nolting. For all who are concerned in any way with municipal work, this Year Book is a most valuable publication. The first part, covering 200 pages, is devoted to governmental units, and contains a 96-page map section. There is extensive data on cities of over 5000 population, information on state municipal leagues, and related items. The second part, of 50 pages, covers municipal personnel followed by a discussion on municipal finance. There is a 250-page section devoted to municipal activities with pertinent reports and statistics. One of the very valuable portions of the book provides directories of officials. There is a detailed Index. An interesting addition to the book gives results of a survey of local defense councils, and there is a list of publications relating to defense activities. Copies of the publication can be obtained at $8.50.

Chairman and discussion leaders in the Round Table Discussion on Alternate Alloy Steels and Conservation of Strategic Alloys.—(from left to right) C. M. Parker, American Iron and Steel Institute; S. C. Spalding, Iron and Steel Branch, War Production Board; A. W. F. Green, Pratt & Whitney Aircraft Division, United Aircraft Corp.; W. P. Eddy, Yellow Truck and Coach Manufacturing Co.; John Mitchell, Carnegie-Illinois Steel Corp.; J. H. Jones, Central Alloy District, Republic Steel Corp.; N. I. Stotz, Universal-Cyclops Steel Corp.; V. W. Whitmer, Republic Steel Corp.; Lt. Colonel J. H. Frye, Ordnance Dept., War Dept.; C. H. Herty, Jr., Bethlehem Steel Co.

Alternate Alloy Steels and Conservation of Strategic Alloys

EDITOR'S NOTE.—As indicated previously in this BULLETIN, the Round Table Discussion on Alternate Alloy Steels and Conservation of Strategic Alloys was an outstanding feature of the Annual Meeting. Arranged by John Mitchell, Carnegie-Illinois Steel Corp., the discussers included leading metallurgists, each an authority on the particular problem covered. While scheduled as an "off-the-record" discussion, with the approval of the chairman and the cooperation of those participating we are able to present in the following pages the discussions which the various participants gave. Two of those participating spoke from notes, and were unable to submit their material for publication with this issue.

Raw Materials for Steel Manufacture

By H. J. French[1]

Presented by S. C. Spalding[2]

THE STEADILY expanding requirements of the War Program have changed the pattern of the steel industry's activities to a large degree in a relatively short period of time. As has been stated by others before, this really involves changes in many of the habits of the industry and these are reflected in no small degree in the availability and use of many of the industry's raw materials.

It is not practicable, within the time available, to consider in detail the effects of the war effort on all of the alloying and conditioning materials necessary in the production of steels, including manganese, silicon, chromium, nickel, molybdenum, copper, vanadium, tungsten, aluminum, zirconium, titanium, columbium, and boron. But it is probably safe to say that the conservation activities long since initiated must be continued and perhaps expanded in the future for most of these materials.

There are probably four major steps which need to be considered, either singly or in combination, for each of the elements mentioned. These are:

1. Stimulation of increased production from existing sources.
2. Opening-up of new sources of the raw materials.
3. Conservation in the use of the metals in steel production.
4. Effective utilization of scrap and salvage of unused tonnages.

A few general comments would seem to be in order to point out significant aspects of production, utilization, or conservation of individual elements.

In the case of manganese definite plans have been laid to supplement or partially supplant foreign supply by domestic sources. For the immediate future some further conservation efforts may be needed since a gradual but small increase in the manganese used per ton of steel is now evident. This does not mean that conservation so far has been ineffective, but rather that conservation in certain grades of steel may have been counterbalanced by gradual increases in the production of steels requiring more manganese.

Notwithstanding such circumstances, there is probably enough manganese now and for the future to permit a somewhat larger use in a portion of the alloy steel production. An increase of 0.5 per cent manganese above a usual 0.75 per cent in, say, one-fifth of the expected alloy

[1] Chief, Metallurgical and Specifications Section, Iron and Steel Branch, WPB.

[2] Consultant in Charge, Unit on Tool and Die Steels, Metallurgical and Specifications Section, Iron and Steel Branch, War Production Board, Washington, D. C.

steel production would not place an excessive burden on present supplies, and might be used effectively in chromium conservation or in other ways.

Substitution of manganese for more critical alloys should not blind us to the long-range potential shortage. For example, nickel is immediately "tight," but the source of supply is largely North America. Manganese is temporarily "easy," but if the war lasts long enough we may be badly pinched because we probably never will be independent of imports.

Probably the most significant factor in the supply of silicon is power, and the allocation of electric furnace facilities to silicon at times when the units are not needed for other products. Here, too, the habits of the industry may have to be altered since power efficiency in making high-silicon ferro alloys is less than that in making the lower silicon alloys.

The long-range program for chromium will provide sources which should not be disturbed by happenings outside the Western Hemisphere, but, in the meantime, further conservation of this metal is indicated. Scrap orders are now in preparation to provide for recovery of more chromium from steel scrap.

For any given pattern of production the position of nickel may be determined quite largely on the one hand by the success of conservation measures which lower the nickel levels in steels, and the development of an effective scrap utilization plan on the other. This can be illustrated by pointing out that at the average nickel consumption per ton of alloy steel for the past 5 yr. there would not be enough of the virgin metal for the anticipated 1942 alloy steel production. With large inflexible demands much more complete utilization of nickel in steel scrap in consumers' hands would appear to be mandatory. The recent scrap segregation order is a step in this direction. Estimates by the Nickel Branch, War Production Board, are that industrial scrap, exclusive of the revert within melting plants, amounts to at least 40 per cent of recent monthly allocations of nickel to industry. Only about 17 per cent of this nickel comes back for new production, and it has been pointed out that a larger utilization of the nickel in steel scrap might make a material change in the supply picture of nickel for steels.

Conservation measures for nickel, chromium, and tungsten have placed a heavy burden on other steel alloys, notably on molybdenum. This metal has had its use expanded appreciably and if substitution of molybdenum steels for other constructional and tool steels is not closely controlled, the present rate of depletion of stocks may be maintained or increased.

An especially heavy load has been placed on vanadium by large increases in high-speed tool steel demands, and by a heavy tonnage of large forgings where vanadium operates effectively in structural and quality control. Large increases in volume are projected, but this metal is likely to remain under control and it has been eliminated from most rolled constructional steels.

Definite plans are in force which will result in increased production of vanadium from both foreign and domestic sources. However, it is not to be expected that such increases will be equal to the rapidly growing demands of the war effort.

To conserve vanadium, the amount present in the high-speed steels has been decreased to a minimum in all cases. Some of the high-vanadium grades such as 18-4-2 (tungsten-chromium-vanadium) have been eliminated and the use of vanadium in all other grades of alloy and straight carbon tool steel dropped.

Copper is so urgently needed in the non-ferrous metal fields that its use in steels, even in small amounts around 0.20 per cent, is now repeatedly being questioned. With few exceptions, copper is being eliminated from steel specifications. However, the use of copper with nickel, when these are obtained from monel metal scrap, is in a somewhat different position. Nickel-copper alloy scrap is being produced in appreciable quantities but this is impure, containing small amounts of lead, of no importance to the steel makers but too large to make the scrap useful to the wrought non-ferrous metal manufacturer. High-tensile rolled steels or other nickel-copper alloy steels are outlets while such by-products of the nickel industry remain available.

The use of tungsten has been restricted and for some time usual requirements for high speed tool steels have been allocated on the basis of 25 per cent in the tungsten types and 75 per cent in the molybdenum steels. An expansion program of producing facilities is being actively prosecuted and increased domestic and South American supplies are to be expected. This increase in supply will definitely not be sufficient to allow unrestricted use of tungsten.

The metals zirconium, titanium, and boron, while now in use, deserve further critical scrutiny. Their present roles may perhaps be supplemented by new functions and all can be secured in larger quantities when needed. Ultimately these metals may take some of the load off other alloys in the progressive expansion of the war effort.

Alloy conservation by reduction in alloy contents, or the substitution of one alloy for another, can be developed with greater freedom where the end uses are largely based on mechanical properties than when corrosion resistance, retention of toughness at low temperatures, physical properties like low expansivity, or special magnetic properties, etc., may be required.

Even for some of the latter so-called inflexible uses with respect to one or more alloying elements, it may be possible to promote conservation. For example, in the field of stainless steels the carbon-chromium or copper-chromium types, may, for some environments, provide adequate corrosion resistance when substituted for the nickel-chromium steels to conserve nickel with only the handicap of a modified fabricating technique. Stainless-clad steels may replace solid stainless construction, with a consequent saving in both chromium and nickel.

In the engineering steels, a considerable latitude exists in the utilization of alloying elements which, however, becomes restricted as the size of section is increased and as the hardness required in the treated parts becomes higher. This is very generally known both to consumers and producers and has been utilized effectively in the creation of the so-called National Emergency Steels.

At the present two principal types are represented: (1) manganese-molybdenum steels, and (2) the low nickel-chromium-molybdenum steels. At the time these steels were incorporated into the American Iron and Steel Institute lists, the demands for molybdenum were not nearly

so great as they are today. The combination of molybdenum with increased quantities of manganese to obtain hardenability was a natural one with two of the more freely available elements.

The low nickel-chromium-molybdenum steels are especially attractive as a means for using alloys in steel scrap. The application of these steels is only now beginning to expand industrially, but there is evidence that their response to heat treatment and their mechanical properties are adequate for broad fields of use.

It may be expected that out of the present and future activities associated with the war effort there will come profound changes in the habits of the steel industry, just as this occurred some twenty-odd years ago from World War I. For the immediate present, however, increased production of raw materials, development of domestic resources, the more effective use of alloys, and a more complete utilization of scrap need to be, and are being, coordinated. This applies not only to the constructional steels and inoxidizable alloys like nickel, copper, and molybdenum, but extends to such fields as high-speed steel grindings for which methods of reclamation, based on research, are needed.

Conservation of Aluminum and Manganese

By C. H. Herty, Jr.[1]

Aluminum

In June, 1941, a subcommittee of the American Iron and Steel Institute made a survey of aluminum consumption in the steel industry. This survey indicated that as of January 1, 1941, the consumption of aluminum was 0.698 lb. per ton of ingots. In June, 1941, this consumption had decreased to 0.562 lb. per ton of steel, entirely through the efforts of the industry to conserve aluminum, which it was felt might become critical at any moment. A further survey was conducted in October of 1941 which showed that consumption again was at 0.562 lb. per ton of steel, indicating that the industry had held its position on aluminum during the summer and fall of 1941.

In order to illustrate the means adopted for bringing about reduction in aluminum consumption, Fig. 1 has been prepared to show, at a given plant, the various steps that were used to decrease aluminum consumption. These steps involved an increased consumption of 50 per cent ferrosilicon, silicomanganese, alsifer, and titanium, and a very careful check on all practices involving the addition of aluminum in order that this addition should be kept at a minimum consistent with steel quality. It will be noted from this chart that aluminum decreased from about 1 lb. per ton in early 1941 to as low as 0.32 lb. per ton in August, 1941, averaging slightly under 0.50 lb. per ton, after the conservation program had set in.

The interchangeability of aluminum with other deoxidizers in certain grades of steel makes it possible to balance deoxidation practices depending on the current supply of the various alloys involved in addition to the aluminum position at any given time.

[1] Assistant to Vice-President, Bethlehem Steel Co., Inc., Bethlehem, Pa.

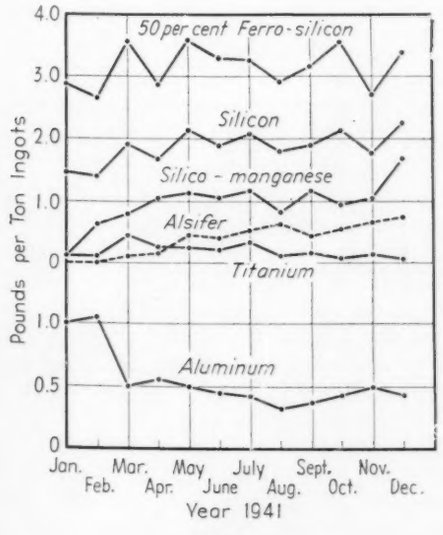

Fig. 1.

Manganese

The consumption of manganese in the steel industry is currently about 12.5 lb. per net ton of ingots. This represents a slight increase over the consumption in 1940 and is a result of the decreased tonnages of low-manganese steels, under 0.40 manganese, the increased tonnages of steels in the range of 0.50 to 1.00, and the increased production of the higher-manganese grades, balanced against the efforts which have been made to date on manganese conservation. It can be roughly stated that a decrease of 1 lb. of manganese per ton is equivalent to lengthening our manganese reserves by 1 month, or that such a decrease will allow a much higher tonnage of high manganese

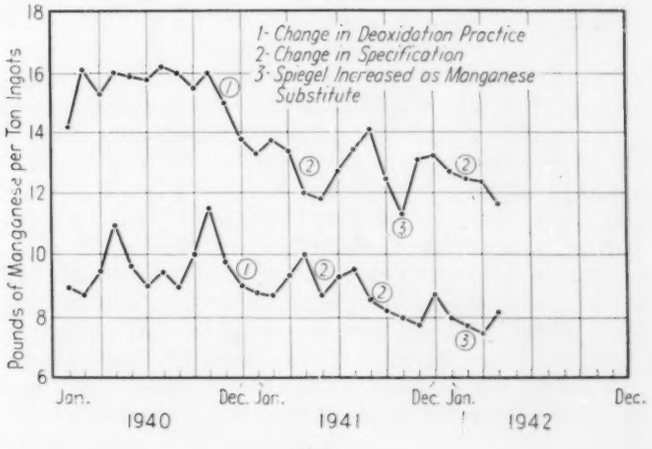

Fig. 2.

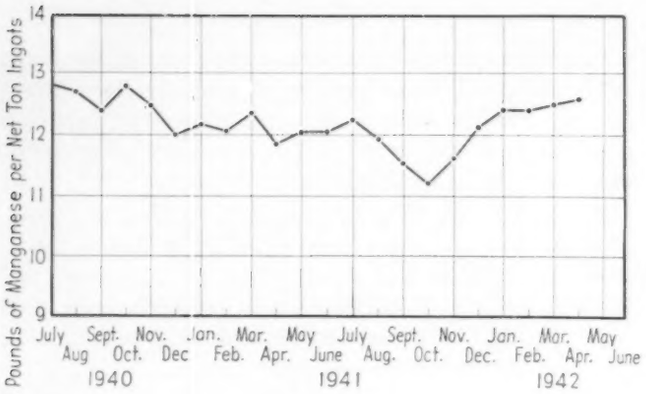

Fig. 3.

steels to be produced without a greater rate of over-all manganese consumption. This is extremely important at the present time because the situation on future importations of manganese ore is uncertain, and domestic production of manganese ore is as yet relatively small and cannot be expected to be a major factor for about 2 yr.

Taking the broad view of manganese as a necessity in all grades of steel and as a potential alloying element for the replacement of other alloys it becomes vitally necessary to do our utmost to reduce the manganese consumption in those steels where manganese is not specified as a true alloying element or where it is accepted as a replacement of other more critical alloys.

Manganese conservation can be accomplished by changes in practice or changes in specifications. Some of these specifications are in the hands of steel producers and others entirely in the hands of the consumer. As has been mentioned previously, conservation to date has been balanced by the increase in manganese content due to changes in types of steel produced so that further efforts must be made in conservation if we are to hold our position, and at the same time make use of manganese as an alloying element in alloy steels. The steel producer has already accomplished a great deal in decreasing his use of manganese and it is believed that the next major step in conservation must come through the efforts of those who are responsible for specifications. Figure 2 shows the results of conservation efforts in two different open-hearth plants where the grades of steel have not been materially changed in the past 2 yr. In one of these plants, manganese consumption has been decreased from about 16 lb. per net ton to about 12 lb. per net ton, and in the other from about $9^1/_2$ lb. per net ton to about 8 lb. per net ton through:

1. Changes in deoxidation practice including
   (*a*) Increasing the amount of manganese added to the ladle and decreasing that added to the furnace.
   (*b*) Giving a preliminary furnace deoxidation with silicon where this had not previously been done.
2. Changes in specifications on products where the producer sets the specifications.
3. Using spiegel in whatever amounts available as a manganese substitute.

These two plants illustrate what can be done in manganese conservation by attempting a good many changes and watching the manganese practice at all times.

Figure 3 shows the effects of manganese conservation and changes in grades of 11 shops and shows clearly how increased amounts of high manganese consumption steels in the past 5 months have increased manganese consumption to the extent that manganese conservation as illustrated by the period July, 1940, to November, 1941, has just about been offset by the increased production of the higher manganese grades. This curve illustrates the necessity for continuing the work on conservation as a means of:

1. Lengthening out the usable period of our manganese stocks.
2. Increasing the availability of manganese as a substitute for other more critical alloys.

Materials Conservation in the Ordnance Department

By J. H. Frye[1]

"Conservation" has many definitions, but whatever the words, the act consists of the effective engineering application of materials. From a military point of view, generalities, sweeping decisions, excessive committee activities, or plain "doing without" have no place in conservation efforts. Conservation is often the correction of past wastefulness, occasioned by the normal overabundance of materials in this country. It is a hard-headed, materials-engineering job; a study of service functions and requirements; and a common-sense consideration of the cost of service failures.

Only in the penalty imposed for service failures do industrial and Ordnance engineers differ—the one costing dollars, the other the lives of our own men, perhaps a battle—or even the war. That is why Ordnance design and materials application cannot be based upon opinions, or reasons other than sound engineering backed up by proving ground tests. Proper functioning Ordnance materiel in the hands of our soldiers is the conservation of our country; we cannot let it down with inferior equipment.

The necessity for materials conservation and the opportunity of saving enormous quantities in Ordnance materiel were recognized a year and a half ago by the Ordnance Department. This is emphasized by the fact that in spite of the millions of drawings which must be reviewed, an order was issued that required a detailed report on every Ordnance part using 1 per cent or more of certain critical alloys. As the list of critical and strategic materials grew, it was apparent that better organization was required to deal with this problem. Consequently, by order of the Chief of Ordnance, a conservation unit was established in each of the four operating divisions, that is, the Tank and Combat Vehicle Division, the Small Arms Division, the Artillery Division, and the Ammunition Division. A centralized authority was established in

[1] Lieutenant Colonel, Ordnance Dept., War Dept., Washington, D. C.

Research and Engineering, Industrial Service, whose duty it was to coordinate and supervise the activities of the Division units. The earlier system was essentially followed, that of requiring detailed reports on all parts containing an appreciable quantity of critical materials or alloys. An engineering study by the responsible design section, the Division Conservation unit, or the Central Conservation Section then determines the possibilities of substitutions or otherwise effecting conservation.

When the use of alternate materials is possible, there are three natural classes in which all parts may be grouped. These are:

1. Those not involving design changes and requiring limited testing before a decision can be reached.
2. Those not involving design changes but requiring more extended testing.
3. Those requiring redesign, or extensive development work.

The work in the first class has been completed and has extended well into the second group. Several projects falling in class 3 are under way. Activity in this direction is limited only by the capacity for such work without interference with production.

In a sense, conservation has only begun, but with the cooperation of all agencies of the Ordnance Department, the War Production Board, Industrial Advisory Committees, and the manufacturers, the following known savings have been accomplished:

Nickel	49 000 000 lb.
Chromium	9 700 000 lb.
Vanadium	1 250 000 lb.
Tungsten	17 500 000 lb.

In addition to these alloying elements, you may be interested to know that 170,000,000 lb. of primary aluminum, 12,000,000 lb. of tin, 60,000,000 lb. of rubber, and 700,000,000 lb. of copper have been saved, based on the production requirements for the remainder of 1942 and 1943.

Also it is estimated that considerable unknown conservation has been effected through specification changes, Emergency Alternate specifications, and by manufacturers of completed units.

Conservation efforts are not restricted to the so-called critical materials. It is becoming more difficult to find the common basic materials with which to feed the giant production machine which has been created. Consideration must be given to steel ingot capacity, and to the facilities for forging, casting, or forming of steel. The Ordnance Department has taken important steps in this direction.

Refinements in rifle bore shell forging practices by industry, and adjustments in procurement, have made it possible to save a minimum of 15 per cent of the total net weight of shell forgings. This means a reduction of several thousand tons of steel for the period of September, 1942, to September, 1943.

Modern stamping and forming methods coupled with hydrogen brazing, projection welding, embossing, and other fabricating methods offer opportunities for reduction of weight and increased production, without affecting strength or sacrificing military efficiency. In addition to the Ordnance personnel, a special consultant has been obtained from industry to aid in this work. A large number of parts have already been altered in design, so as to accommodate this method of production, resulting in the use of noncritical stamping facilities and saving considerable steel-making capacity.

A large unused capacity for producing malleable iron castings is available, and, since malleable uses the least critical of ferrous products, it can be used in many instances to replace forgings, steel castings, or rolled products. An increasing tonnage is being specified by the Ordnance Department.

The possibility of using gray iron castings in modern war materiel is more limited. However, it is desired that it be used wherever it can be done without affecting safety or military efficiency. An industrial consultant has been engaged to aid in this activity. Powder metallurgy is also being utilized. In fact, every effort is being made to use the least critical of materials, and fabricate by the least critical of processes, providing, of course, that the required production is maintained, and safety or military efficiency are not jeopardized.

The War Department has adopted many of the NE steels, including them in War Department specifications for bars, sheet and strip, and tubing. The Small Arms Division has specified them for parts for Garand rifles, machine guns, and carbines, and the Artillery and Tank and Combat Divisions have specified them for a great many parts, while making tests for other applications. This is particularly true of the carbon-molybdenum steels, in which an extensive industrial background and experience exists.

The low nickel-chromium-molybdenum NE steels apparently have characteristics which make them valuable for many applications. The lack of experience and data relative to their characteristics has retarded their general use by the Ordnance Department. However, this data is being compiled by industry, while the Ordnance Department is investigating the normal and subzero mechanical and welding properties. When this data is obtained, and the steels become more available, it is likely that they will be used to a great extent.

In this connection, it is my belief that the enthusiasm and sales effort used to make the public conscious of these steels have been somewhat overextended. Many people are of the opinion that these are the only steels that will be available, and have considered or are considering their use as substitutes for less critical grades. It appears to me that the same effort applied to the use of plain carbon steels would result in greater benefits, and save this low-alloy scrap for the manufacture of necessary alloy steels. In addition, the supply of molybdenum is now trailing its requirement, and any increased usage will likely make it as critical as the alloys which it replaces. It is strongly recommended that a more determined effort be made to use plain carbon steels. Perhaps the introduction of a series of supercarbon steels would prove advantageous from both a psychological and practical viewpoint.

I should like to leave the thought that conservation, like evolution, is a process, not a product; and above all, the Ordnance Department is vitally concerned with conservation. By close cooperation with the War Production Board, a great deal has been accomplished, and we have only begun. But, under no circumstances will such effort be permitted to interfere with the safety and reliability of the materiel. War machines are made to kill people—and we are going to be sure that they kill the right ones!

Conservation of Elements Necessary for Tool Steels

By N. I. Stotz[1]

In this discussion references to nickel and chromium will be brief, since the use of nickel in tool steels is infinitesimal and chromium is nearly always used as high-carbon ferrochromium. This has not been difficult so far. Our efforts to date have been in the conservation of

1. Cobalt.
2. Tungsten and/or molybdenum.
3. Vanadium.

The cobalt situation is not too complicated. The 12 per cent cobalt high-speed steel has been eliminated but this is partly due to the vanadium situation. In general, the plan used is to confine the use of cobalt high-speed steels to spots where they are necessary.

Our first problem was tungsten. Even before the present record demand it became apparent that our tungsten resources, plus our dwindling imports from China, could not serve unless the price of high-speed steel skyrocketed to figures reached during the last war. Regardless of price the present demand could not be met under any circumstances.

Fortunately alternate steels already existed. Several of the molybdenum high-speed steels were in wide usage and the extension of their use was eased materially by the background of 8- to 10-yr. experience. Where modern heat treating facilities existed the change was accomplished by merely re-educating the consumer in a new series of hardening temperatures. Some cases required the acquisition of new equipment, but many intermediate cases were solved by the use of protective coatings during hardening.

It had been a long-established fact that tools made of molybdenum high-speed steels of proper chemistry, when correctly heat treated, compared favorably with tungsten high-speed steels and, for various applications, actually gave better service.

The first restriction came as Order M-14 in June, 1941. This order called the molybdenum high-speed steels class A and set such steels up as those containing 0.60 per cent carbon, min., 3.00 per cent molybdenum, min., and 7.00 per cent tungsten, max. The tungsten high-speed steels were called class B and were set up as steels containing 0.55 per cent carbon, min., and 12.0 per cent tungsten, min. The carbon content was defined as above in order to exempt the various hot work intermediate tungsten steels and confine the restrictions to the cutting tools only. As of June 1 any consumer had to buy on a 50-50 basis for any three-month period, that is, for each pound of class B steel he had to purchase one pound of class A steel.

Before the issuance of order M-14 we feel the consumption of high-speed steel was on an 80-20 basis in favor of the tungsten steel. After the first three-month period, orders, but probably not shipments, were on a 60-40 basis in favor of molybdenum types. Orders for tungsten steels existing prior to June, 1941, could be filled so that this backlog kept the actual conservation down temporarily.

Despite the fact that M-14 was able to swing the balance a little better than the intended half-and-half basis it was not sufficient to take care of the situation as the demand increased and the tungsten imports decreased. At the end of October, 1941, the amount of class B (tungsten) permissible was lowered to 25 per cent. This meant 3 lb. of molybdenum high-speed steel had to be used for each pound of tungsten. As a result of this extension the use of molybdenum steel rose to over 80 per cent of the total used.

As of today this 75-25 rule still stands. We have no knowledge of any plans to change it, but we must admit that heavy demands on the molybdenum industry, including export demands, have that element on the verge of restrictions. The balance between molybdenum and tungsten is sensitive and probably varies from month to month. We are not in a position to know the future picture or to make any predictions concerning it.

The vanadium situation presented a much more complicated case to our industry than the tungsten picture. It turned out to be a ground-hog case from many angles. There was just so much available for use and we were given the problem of using what was allotted to us where it was needed most. The industry acted as a unit with WPB and so far has kept close to the quota by adopting the following restrictions effective about March 1, 1942:

1. Vanadium has been dropped from all tool steels other than class A and class B high-speed steels.
2. Class B (tungsten) has had the following restrictions:
   (*a*) The 2 per cent vanadium types, or 18-4-2 are discontinued.
   (*b*) No tungsten high-speed steel is made above 1.10 per cent vanadium except in the presence of 3.5 per cent cobalt or higher.
3. Class A (molybdenum) has had the following restrictions:
   (*a*) No grade is made with more than 1.90 per cent vanadium.
   (*b*) Existing grades are pared down to lower emergency limits. For example, one grade which called for 1.40 to 1.75 per cent vanadium limits has been set down to 1.30 to 1.60. In the regular low vanadium range of 1.00 to 1.35 the general practice has been to melt 1.00 to 1.20.

Even in the face of these cutbacks the industry is today under request to conserve a further 10 per cent of our allotments. This is generally being accomplished by three methods:

1. A further fractional reduction of the vanadium content.
2. A revised distribution of grades where lower vanadium high speeds can be used.
3. Increased percentage of scrap in the melting charge.

[1] Metallurgical Engineer, Universal-Cyclops Steel Corp., Cyclops Division, Titusville, Pa.

As to the effect of these vanadium restrictions on tool efficiency we have no great concern for the general tool steels other than high-speed steel.

In the case of high-speed steels there will undoubtedly be some loss of cutting efficiency. How much, no one knows as yet. One saving factor is that in the past many tools were made from the superhigh speeds when the service did not actually require such steels, but where the service did justify them the absence of vanadium will be noticed.

We do not have comprehensive test data that gives us a clear picture but recently the author has been shown a series of well-conducted tests on standard 18-4-1 compositions with 1.00 per cent vanadium, 0.50 per cent vanadium, and 0 per cent vanadium. Using the 1.00 per cent vanadium as par, the vanadium-free tools showed a 52 per cent efficiency, but the 0.50 per cent vanadium tools showed 88 per cent efficiency.

This test would indicate a curve with a rather steep slope and would lead us to feel that if we had to go under 1.00 per cent average vanadium in our regular high speeds, say, down to 0.80 per cent vanadium, we would still expect around 92 to 95 per cent cutting efficiency.

If we get through this emergency with no less hurt than that, we will all be fortunate indeed. The most encouraging part of this picture to us is the wholehearted cooperation of the consuming trade who seem to realize the problem and make the best of it.

Conservation of Alloys in Stainless Steels

By W. W. Whitmer[1]

In view of the conservation of all strategic materials at the present time, the stainless steels with their high alloy content have required immediate consideration.

The straight chromium group holds forth little promise of any reduction or substitution of alloy, since chromium is about the only element offering corrosion-resisting properties in the stainless category. The low chromium-molybdenum steels, with around 2 per cent chromium and 0.5 per cent molybdenum, are used for still tubes, the chromium is increased up to 5 and 7 per cent when more corrosion resistance is demanded. Then follow the valve steels and low heat-resistant alloys with chromium around 9 per cent. Next are the so-called stainless products with chromium starting at 12 per cent and further increased to about 18–20 per cent as additional corrosion-resisting properties are demanded. Above this, up to 30 per cent, are the true heat-resistant straight chromes with the actual alloy content dependent on the demands.

It is readily apparent, therefore, that any reduction in chromium would be accompanied by a corresponding drop in corrosion and heat-resisting properties. But by the same token definite conservation could be attained by a careful study of each application by the designing engineer and the consumer to permit use of the lowest alloy commensurate with safety. That is, use a 12 per cent chrome type, such as type number 410, wherever possible instead of the more common 18 per cent chromium type, 430, and follow the same procedure with the still higher alloys even though the total expected life may be somewhat less.

The chromium-nickel alloys seem to offer somewhat better possibilities. The high tensile type, that is the 17 per cent chromium – 7 per cent nickel, could be slightly reduced in nickel with a little increase in manganese. The industry has already produced several hundred tons replacing about half the nickel with manganese, though roughly twice as much manganese is required as the nickel content saved. This decision depends therefore on the ratio of strategic metal. Much difficulty was encountered with this chemistry at first and though it is still more troublesome than the 17–7 type it has been produced on a commercial basis.

The aircraft industry uses much 17–7 or 18–8 high tensile strip for skin coverings, structures, cowlings, fire walls, and auxiliary equipment, such as ammunition boxes, chutes, etc., all fabricated by forming and spot welding. There is a movement on foot now to replace some of these with low-carbon chromium-molybdenum and nickel-molybdenum of the 4100 and 4600 series and even the NE series of chromium-nickel-molybdenum types in the high tensile ranges. In cases where it may be desirable to retain stainless types such as in fire walls, cowlings, etc., which are exposed to heat and the elements, 17–7 should be retained although there may be a possibility of fire walls using a lower straight chrome of the 12 per cent chromium type, with low carbon and columbium or aluminum to reduce hardening on spot welding operations. Such steels, along with the 4 to 6 per cent chromium-molybdenum type and coated mild steel are receiving much consideration right now. None of these steels, however, will have such high physical properties as 17–7 and hence will carry some weight penalty. Any substitution will therefore require careful study.

The 18–8 and 20–10 regular and low-carbon types offer little hope of conservation other than careful application, such as not using or specifying low carbon where higher carbon will be satisfactory. There are undoubtedly many applications using these chromium-nickel alloys where the straight chromium could be very easily substituted. This would apply to certain phases of the chemical and process industries, food and dairy processing, as well as many others. Each one, however, would require an individual analysis, both as to use and fabrication, including design. A good example of such substitution is the large quantity of type 430 straight chromium mess trays recently produced, which were originally drawn from chromium-nickel type 302.

Considerable help should result from recent changes in specifications covering 18–8 stabilized with titanium or columbium raising the carbon to 0.10 per cent max. and modifying the titanium and columbium to 4 and 8 times the carbon content, respectively. This will give the steel

[1] Republic Steel Corp., Massillon, Ohio.

mills an opportunity to remelt stainless scrap, thereby recovering the alloys, which is equivalent to a high degree of conservation of chromium and nickel. Some further saving could be made by reduction of alloys in these grades from a service standpoint, but experience has taught us both in rolling and fabricating that the higher nickel ranges are the most economical in the finished parts. These same factors apply to 18–8 stabilized with molybdenum though for the most part type 316 with the lower alloy should suffice for all applications for the duration.

The high chromium-nickel alloys 25–12, 25–20, etc., are used mostly for heat resistance when necessary and hence constitute a small field with the exception of welding rod. Type 25–20 is used in fairly large quantities in welding electrodes and chemistry is held on the high side of the range. Numerous tests have been made to lower the alloy content and it appears now these alloys will very likely be reduced. One application which started with 25–20 welding electrodes has been changed to 18–8, modified with either molybdenum or manganese. Further experimental work is now in progress which may entirely change the austenitic electrode to a ferritic type carrying very little alloy. This is a possibility at the present time.

In the chromium-nickel ferritic field, the 16 chromium-2 nickel type could in many cases be reduced to 14–2 with a chromium saving, since both are heat-treatable grades and the corrosion resistance would be only slightly reduced and may not be a factor at all for many uses. There is also a good possibility that some applications of the 17–7 high-tensile type could be reduced to 14–2 by fabricating and heat treating the finished article.

There are some steels used at high temperature where high strength is the primary requirement. Many have regularly used tungsten but recent developments have shown molybdenum can be substituted with very good results. This would permit the use of two alloys for high-temperature - high-strength applications which could be used interchangeably depending on availability.

Summing up the possibilities for conservation of alloys in stainless and heat-resisting steels, there are a few substitutes and new products available. Recent changes will permit more reclamation of alloy from scrap and numerous experiments are in progress for use of lower alloys; but probably the greatest conservation can be obtained by more careful study of each item and use of the lowest possible alloys which are now in commercial production.

The National Emergency Steel Compositions

By Charles M. Parker[1]

An old Eastern proverb reads, "Be not overjoyed at great riches for Allah will provide a need therefor." One could apply the philosophy of that proverb to America and its use of the elements which go to make alloy steel.

In the field of alloy steels American industry has been careless. We have been lavish in the use of alloying elements, seeking always foolproof steels which could stand abuse in fabrication and heat treatment and still stand up under the punishment given them in the field. Our efforts to secure the maximum effect on physical properties from the minimum quantity of a given alloying element, or combination of alloying elements, have not been too searching, up to now.

Now, Allah has provided the need and we are faced with the real problems of scarcity from which there is no immediate escape, and our native ingenuity rises and we find newer and leaner alloy steels which are in many cases proving to be superior to the older and richer alloy steels. The leaner alloys of which I speak are the NE or National Emergency steel compositions, now familiar to all of you.

Before discussing the development of those compositions in detail, it seems desirable to touch on a few of the events which led up to the cooperative effort which made possible the accomplishment of so much fundamental work in so short a period of time.

You all know that in May, 1941, American Iron and Steel Institute published its first lists of Standard Steels. Those lists covered 60 carbon steel compositions and 76 alloy steel compositions, all of which were selected by composition limits from the records of steel producers according to the tonnage of each produced.

In both cases the compositions listed covered approximately 94 per cent of the total tonnage of semifinished products, bars, rods, and alloy strip which were produced during 1940.

It is interesting to know that the 136 compositions listed were selected from some 4000 compositions current in the files of steel manufacturers. In other words, some 3800 compositions comprised only 6 per cent of the total tonnage of the products under consideration.

It was recognized that within that 6 per cent there were many steels of proved merit which by reason of their limited use could never be standardized on a tonnage basis. An orderly method of specifying composition ranges and limits for such steels was devised and published. That method also ensures orderly procedure in developing research projects as will be seen later.

In January of this year joint meetings were held by the Iron and Steel Division of the Society of Automotive Engineers and representatives of the Technical Committees of the Institute. All the data which were used by our Technical Committees were made available to S.A.E. and as a result a single list of steel compositions now replaces the individual lists of the two organizations.

An important departure from practices heretofore adhered to by consumers is that the present lists of standard steels are based on ladle analysis ranges to which check analysis limits are added. The check limits are based on the natural phenomena which accompany the freezing of an ingot, the size of cross-section to be sampled and the type of steel involved: killed, semikilled, or rimming. This plan, which displaces the older fixed ranges and limits has resulted in closer check limits than have been used heretofore and is another step forward on the road of improved uniformity. (See Fig. 1.)

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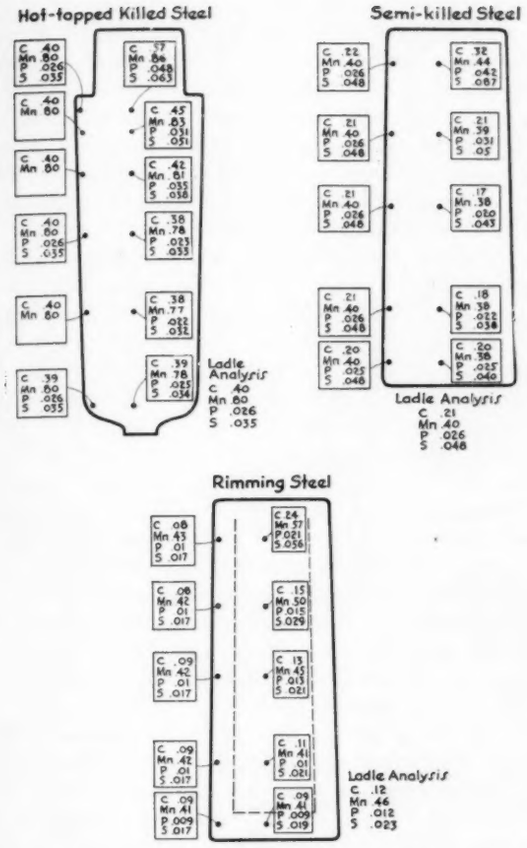

Fig. 1.—Differences in Normal Segregation in Various Types of Steel.

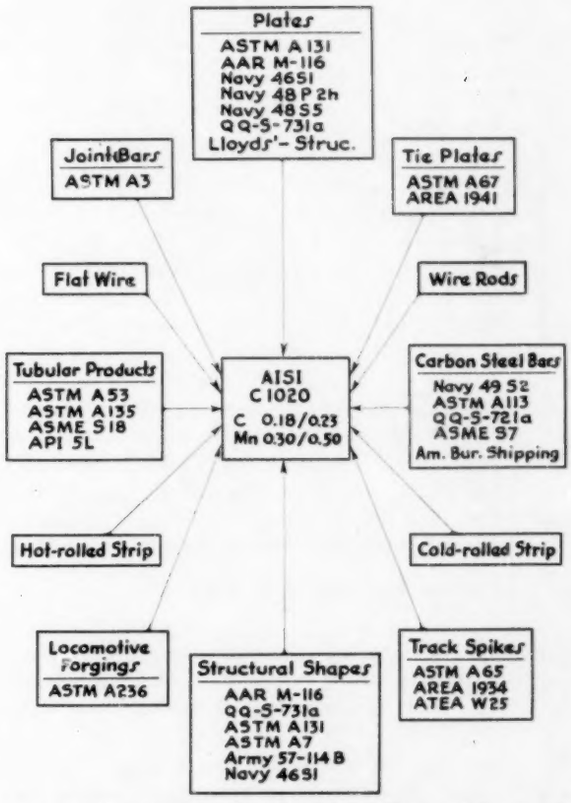

Fig. 2.—Application of a Standard Steel Composition to Commodity Specifications.

Figure 2 illustrates the application of a standard steel composition to several commodity specifications.

Some weeks before the nickel shortage became generally known, the Committee on Manufacturing Problems of the Institute requested the Technical Committee on Alloy Steel to prepare a factual schedule of possible alternates for nickel steels. The results of the Committee's work have been published under the title, "Possible Substitutes for Nickel Steels." That work enjoyed a unique welcome in the field of material substitution, providing as it did sound technical recommendations for substitute steels containing little or no nickel.

In recommending alternates for nickel steels, chromium and molybdenum were drawn on freely. Partly as a result of that, partly as a result of the reduction in sources of supply for chromium, and partly as the result of a shift which had started well before the war, chromium is now restricted in the same manner as nickel. Accordingly, the Technical Committee on Alloy Steel developed alternates for chromium and nickel-chromium steels which are now known as the NE series or National Emergency Steels, and which were published by the Institute under the title, "Possible Alternates for Nickel, Chromium and Chromium-Nickel Constructional Alloy Steels."

In devising alternates for nickel, chromium, and nickel-chromium constructional alloy steels, full use was made of the cooperative method of devising steel compositions. Members of the Technical Committee on Alloy Steel met with members of the Iron and Steel Division of the Society of Automotive Engineers and other interested parties, laid out a plan of action taking into consideration not only the immediate shortages of nickel and chromium, but looking into the future a bit to see what the scrap situation might be in an effort to take maximum advantage of any opportunities that might become apparent.

It was well known that the residual contents of nickel, chromium, and molybdenum were rising in both recycled and purchased scrap and, accordingly advantage was taken of that fact in the NE 8600, 8700, 8800, and 8900 series.

The experience of one large producer of alloy steels in melting nickel steel heats is summarized in Fig. 3. It is evident that in the field of low-nickel steels, whether of simple or complex composition, more than 90 per cent of the nickel called for by specification ranges is being recovered from steel scrap.

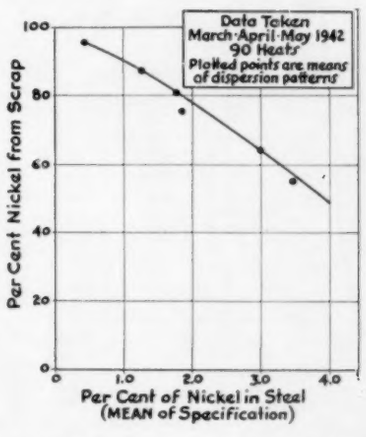

Fig. 3.—Recovery of Nickel from Scrap.

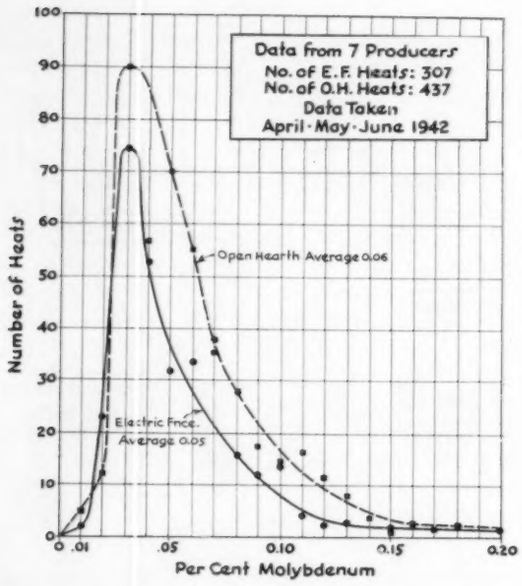

Fig. 4.—Residual Molybdenum in Nickel-Chromium Steel.

Figures 4, 5, and 6 show the incidence of molybdenum in nickel-chromium steels, of nickel in chromium-molybdenum steels, and of chromium in nickel-molybdenum steels.

By combining the incidental or recoverable nickel, chromium, and molybdenum from scrap with small quantities of virgin metals or ferro-alloys, it was apparent that a saving in the over-all use of all such elements would be made.

It must not be assumed, however, that because a substantial portion of the alloy content of the nickel-chromium-molybdenum NE steels is derived from scrap, any important "dollars-and-cents" economy accrues to the steelmaker. On the contrary, the difficulties and expense involved in testing and segregating scrap more than offset the dollar value of the alloying elements conserved.

As an example of the difficulties which would be faced in melting practice without such a series of alternate steels as those under discussion, one prominent producer of alloy steels reported that of 116 heats charged during May, 81 melted satisfactorily as charged and 35 melted outside specification limits. Of the 35 heats that failed to qualify, 14 were high in nickel, chromium, and molybdenum and were converted to alternates. Three heats which were charged as straight nickel steel were too high in chromium or molybdenum, or both, and were made into chromium-nickel or nickel-molybdenum steels. Eleven heats which were charged as straight chromium steels melted over 0.25 per cent nickel and were converted to alternates. Seven heats which were charged as chromium-molybdenum steels melted too high in nickel and were converted to nickel-molybdenum steel, with a chromium content below the permissible residual. Of the 35 heats converted 25 were converted to alternate steels.

The only other alloying elements which appeared to be available to the industry in not too restricted quantities were manganese and molybdenum. The reputation of manganese-molybdenum steels as used in Great Britain for a number of years was carefully considered; English experience was checked and English compositions examined carefully. It was the opinion of our people that a good series of manganese-molybdenum steels could be made, using less manganese and less molybdenum than English practice demands.

With the program set that far, all available hardenability data were collected and studied. It was apparent from the information that certain experimental work would have to be performed. Therefore, a program was laid out in which steel producers and producers of ferro-alloys melted experimental heats of the new compositions and secured hardenability curves for each steel.

Because an excessive amount of time would have been consumed in making standard tensile and other physical property tests of all the alternate compositions, the committee was of the opinion that for general applications a comparison of standard end-quench hardenability data would suffice as a guide to application of the alternate steels.

That decision was based on the well-known fact that

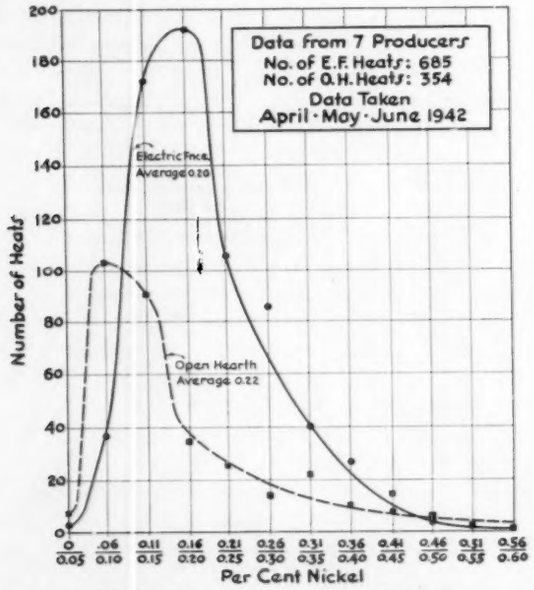

Fig. 5.—Residual Nickel in Chromium-Molybdenum Steel.

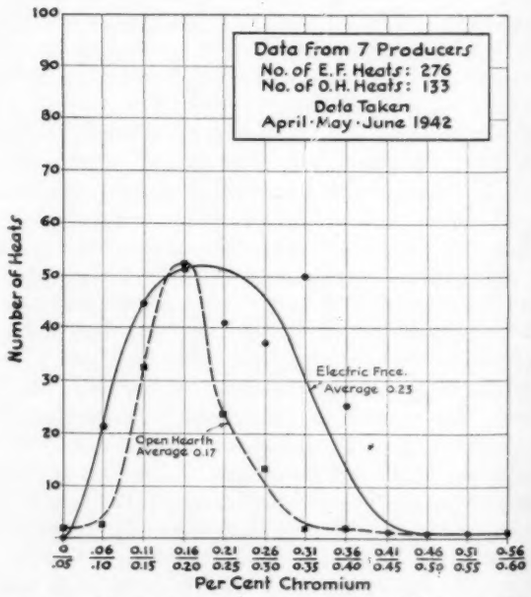

Fig. 6.—Residual Chromium in Nickel-Molybdenum Steel.

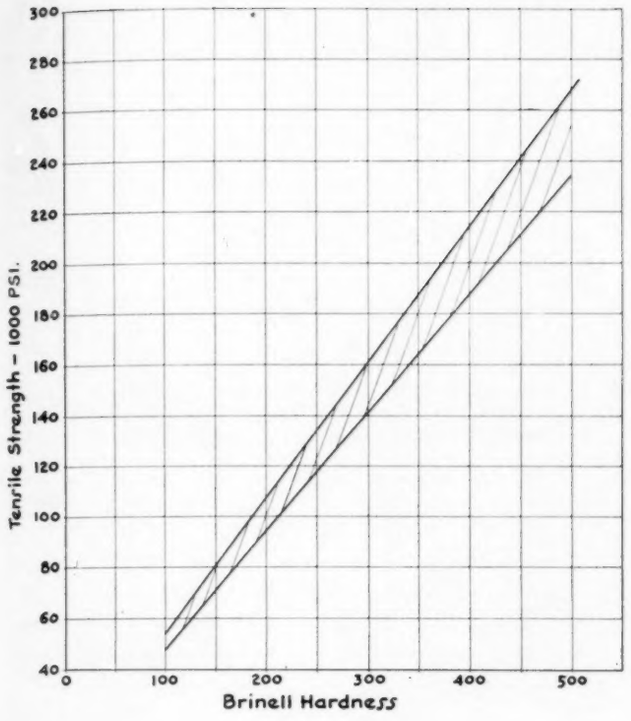

Fig. 7.—Relation Between Hardness and Tensile Strength.
Source of information: General Motors Research Labs.

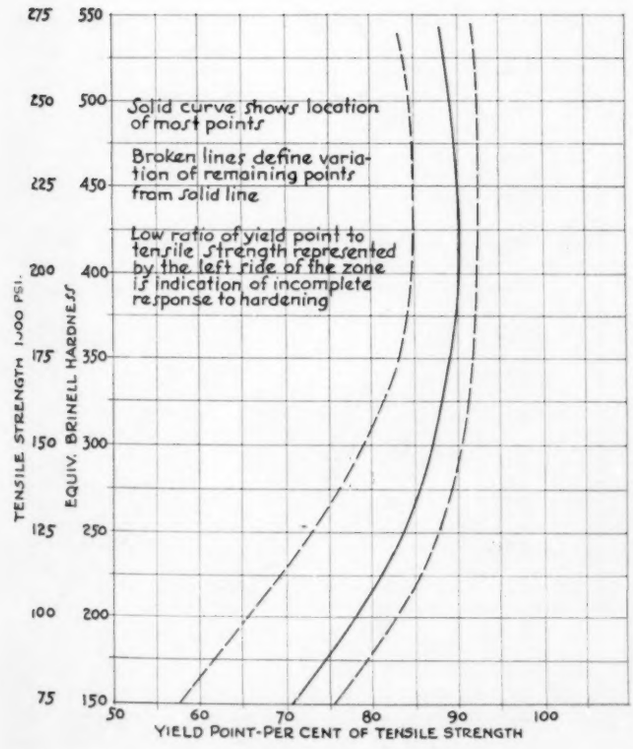

Fig. 8.—Relation Between Tensile Strength and Yield Point, in Per Cent of Tensile Strength.

For 0.30 to 0.50 per cent carbon content of series 1000, X1300, 1300, 5100, 4100, 4300, 4600, 3100, 3200, 2300 and 6100 steels in the quenched and tempered condition.

Source of information: General Motors Research Labs.

hardness is related to tensile strength, yield point, and ductility as measured by reduction of area. Regardless of composition, steels of the same hardness, produced by tempering after hardening, will have the same tensile strength and yield point, provided that the original quenched structure is substantially martensitic.[2] Excellent data exist from which those characteristics can be calculated within reasonable limits of precision.

Let us assume that on the day that "Possible Alternates for Nickel, Chromium, and Chromium-Nickel Constructional Alloy Steels" was published, a metallurgist in an industrial plant was faced with the problem of selecting an alternate for A 3140. Let us make the further time-saving assumption that because he had heard of English experience with manganese-molybdenum steels he selected NE 8442 from the table of compositions as one which might do the job. No physical property data were available to him, except the hardenability curves published in the "alternate" book. How is he to get sufficient information to justify his use of NE 8442?

First, he might compare composition hardness values derived from data published in many steel handbooks. A comparison based on one such system[3] and using the means of the composition ranges given for the two steels is as follows:

COMPOSITION HARDNESS COMPARISON.

Element	A 3140				NE 8442			
	Content, × 100		Hardening Factor	Value	Content, × 100		Hardening Factor	Value
Carbon	40	×	30	1200	42	×	30	1260
Manganese	80	×	8	640	145	×	8	1160
Phosphorus	4	×	40	160	4	×	40	160
Sulfur	4	×	10	40	4	×	10	40
Silicon	28	×	5	140	28	×	5	140
Nickel	125	×	4	500	...		..	..
Chromium	65	×	5	325	...		..	...
Molybdenum	...		..	...	35	×	16	560
	Comparison Number			3005				3320

The comparison numbers indicate that the manganese-molybdenum steel will have a higher hardness than the nickel-chromium steel and therefore a higher tensile strength.

Referring now to the book of "alternates" a standard end-quench hardenability curve is found[4] which compares the hardness characteristics of the two steels and it is found that the curves compare favorably—the manganese-molybdenum curve being somewhat higher than the curve for the nickel-chromium steel—as was indicated by the composition hardness computations. The manganese-molybdenum steel data are from a 10-ton open-hearth experimental heat (grain size 7) which has the following composition, and composition hardness rating:

Element	Content, × 100		Hardening Factor	Value
Carbon	42	×	30	1260
Manganese	125	×	8	1000
Phosphorus	2	×	40	80
Sulfur	1.9	×	10	19
Silicon	23	×	5	115
Molybdenum	33	×	16	528
	Comparison Number			3002

The comparison number gives an almost exact check

[2] Edgar C. Bain, "Functions of the Alloying Elements in Steel," American Society for Metals, Cleveland, Ohio (1939).

[3] "Bethlehem Alloy Steels," p. 164.

[4] "Possible Alternates for Nickel, Chromium, and Chromium-Nickel Constructional Alloy Steels," p. 118.

with the composition hardness value of A 3140. On consulting Fig. 7 which relates hardness to tensile strength it is found that 310 Brinell, the hardness at which the steel is to be used, is equivalent to a tensile strength of 158,000 psi. On consulting Fig. 8 which shows the relationship between tensile strength and yield point in percentage of tensile strength, it is found that for 158,000 psi. tensile strength a yield point of 137,000 psi. (0.87 tensile strength) is indicated.

The indicated tensile strength reflects a reduction of area of 54 per cent, with a possibility of a range of 48 to 58 per cent as shown in Fig. 9. This property is predictable only when the steel has been tempered to below 400 Brinell.[5]

Reference to Fig. 10 which gives the relationship between hardness and tempering temperature indicates that the steel should be tempered at approximately 1150 F.

In this connection, Bain[5] states that "when the several steels are carefully compared at the same hardness by the choice of appropriate tempering temperatures, the tensile properties are amazingly similar."

Sufficient information is now available for one who is well-grounded in fundamentals to make a decision. A further check can be made, however. Consultation of comparative physical property charts affords the following comparison at 300 Brinell:

PHYSICAL PROPERTIES.

	Actual Properties,[a] A 3140	Calculated Properties, NE 8442
Tensile strength, psi	145 000	158 000
Yield point, psi	120 000	137 000
Reduction of area, per cent	58	54

[a] "Possible Alternates for Nickel, Chromium, and Chromium-Nickel Constructional Alloy Steels," p. 78.

Sometime later actual test data[6] became available at 311 Brinell as follows:

Tensile strength, psi	156 000
Yield point, psi	140 000
Reduction of area, per cent	56

If one metallurgist had elected to use NE 8739, the computations would have been as follows, to secure 311 Brinell:

COMPOSITION HARDNESS COMPARISON.

Element	A 3140 Content, × 100	A 3140 Hardening Factor	A 3140 Value	NE 8739 Content, × 100	NE 8739 Hardening Factor	NE 8739 Value
Carbon	40	× 30	1200	39	× 30	1170
Manganese	80	× 8	640	88	× 8	704
Phosphorus	4	× 40	160	4	× 40	160
Sulfur	4	× 10	40	4	× 10	40
Silicon	28	× 5	140	28	× 5	140
Nickel	125	× 4	500	50	× 4	200
Chromium	65	× 5	325	50	× 5	250
Molybdenum	...	..	...	25	× 16	400
	Comparison number		3005			3064

The comparison numbers indicate that the nickel-chromium-molybdenum steel will be of the same order of hardness as the more richly alloyed nickel-chromium steel and, therefore, equivalent tensile properties.

[5] Edgar C. Bain, "Functions of the Alloying Elements in Steel," American Society for Metals, Cleveland, Ohio (1939).

[6] Supplementary information, April 30, 1942, Sec. 10, Sheet 9.

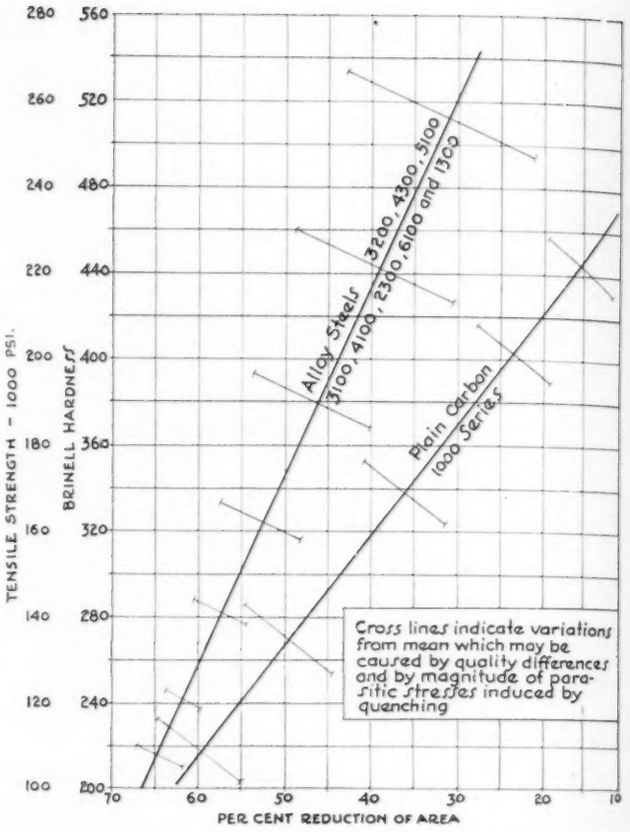
TENSILE STRENGTH - 1000 PSI.
BRINELL HARDNESS
PER CENT REDUCTION OF AREA
Alloy Steels 3200, 4300, 5100, 3100, 4100, 2300, 6100 and 1300
Plain Carbon 1000 Series
Cross lines indicate variations from mean which may be caused by quality differences and by magnitude of parasitic stresses induced by quenching

Fig. 9.—Relation Between Tensile Strength and Reduction of Area.

Source of information: General Motors Research Labs.

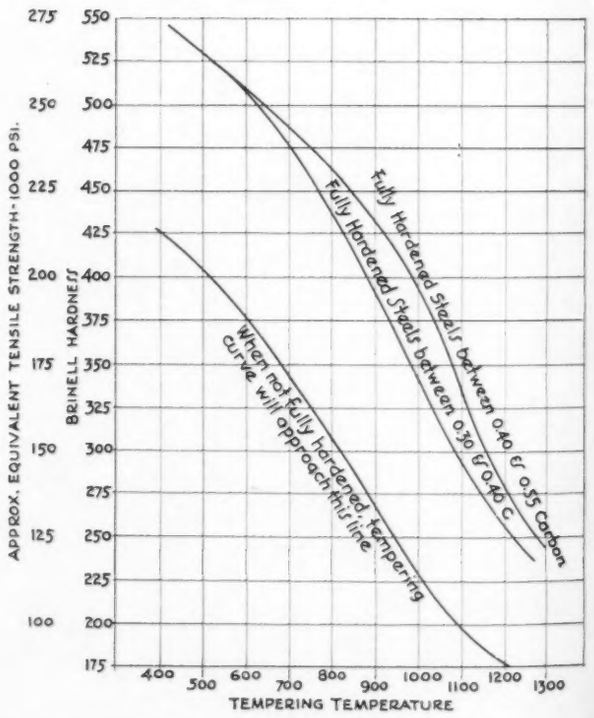
APPROX. EQUIVALENT TENSILE STRENGTH - 1000 PSI.
BRINELL HARDNESS
TEMPERING TEMPERATURE
Fully Hardened Steels between 0.40 & 0.55 Carbon
Fully Hardened Steels between 0.30 & 0.40 C.
When not fully hardened tempering curve will approach this line

Fig. 10.—Relation Between Hardness and Tempering Temperature.

Summary of data on carbon and alloy steels including series 1000, 1300, 3100, 3200, 4100, 2300, 4600, 5100, and 6100.

Source of information: General Motors Research Labs.

TABLE I.—ALTERNATE STEELS.

Designation	Chemical Ranges or Limits, per cent				
	Carbon	Manganese	Molybdenum	Nickel	Chromium
NE 8024	0.22 to 0.28	1.00 to 1.30	0.10 to 0.20	...	...
NE 8124	0.22 to 0.28	1.30 to 1.60	0.25 to 0.35	...	...
NE 8233	0.30 to 0.36	1.30 to 1.60	0.10 to 0.20	...	...
NE 8245	0.42 to 0.49	1.30 to 1.60	0.10 to 0.20	...	...
NE 8339	0.35 to 0.42	1.30 to 1.60	0.20 to 0.30	...	...
NE 8442	0.38 to 0.45	1.30 to 1.60	0.30 to 0.40	...	...
NE 8447	0.43 to 0.50	1.30 to 1.60	0.30 to 0.40	...	...
NE 8547	0.43 to 0.50	1.30 to 1.60	0.40 to 0.60	...	...
NE 8620	0.18 to 0.23	0.70 to 0.95	0.15 to 0.25	0.40 to 0.60	0.40 to 0.60
NE 8630	0.27 to 0.33	0.70 to 0.95	0.15 to 0.25	0.40 to 0.60	0.40 to 0.60
NE 8724	0.22 to 0.28	0.70 to 0.95	0.20 to 0.30	0.40 to 0.60	0.40 to 0.60
NE 8739	0.35 to 0.42	0.75 to 1.00	0.20 to 0.30	0.40 to 0.60	0.40 to 0.60
NE 8744	0.40 to 0.47	0.75 to 1.00	0.20 to 0.30	0.40 to 0.60	0.40 to 0.60
NE 8749	0.45 to 0.52	0.75 to 1.00	0.20 to 0.30	0.40 to 0.60	0.40 to 0.60
NE 8817	0.15 to 0.20	0.70 to 0.95	0.30 to 0.40	0.40 to 0.60	0.40 to 0.60
NE 8949	0.45 to 0.52	1.00 to 1.30	0.30 to 0.40	0.40 to 0.60	0.40 to 0.60

The nickel-chromium-molybdenum steel has the following tensile properties calculated from 277 Brinell:

Tensile strength, psi	136 200
Yield point, psi	117 100
Reduction of area, per cent	62
Tempering temperature	1150 F.

It is evident that the steel will not meet desired physical properties at 277 Brinell; therefore, an adjustment in heat treatment is necessary. On consulting Fig. 6 it is found that to secure 311 Brinell, it will be necessary to draw at 1050 to 1100 F.

A recalculation of the expected tensile properties based on the new drawing temperatures gives the following:

Tensile strength, psi	148 000 to 157 000
Yield point, psi	128 700 to 138 100
Reduction of area, per cent	56 to 54

Some time later, actual test data[7] became available at 311 Brinell as follows:

Tensile strength, psi	155 000
Yield point, psi	140 000
Reduction of area, per cent	55
Tempering temperature	1100 F.
Brinell hardness number	311

From the foregoing it is evident that the resourceful man has tools at his disposal to assist him in selecting alternate steels without danger of serious error.

[7] Supplementary information, May 18, 1942, Sec. 10, Sheet 55.

The hardenability data were accumulated from members of the committee and were compared in detail to determine how the characteristics of the proposed alternates would compare with the characteristics of well-known steels. That information was then condensed and adjusted to conform with the availability of raw materials, the standard ranges previously mentioned and the desire to present the smallest possible number of alternate combinations which might satisfy the greatest number of needs. Those alternate steels are given in Table I.

Work on testing and accumulating standard tensile and other physical property data has continued. Up to now the Institute has published about 120 curves giving much of those data which were made possible through the generous cooperation of consumers and steel manufacturers alike.

The numbering system used to designate the National Emergency steels was set to conform with the standard numbering systems used by both the Society of Automotive Engineers and the Institute, with the thought in mind that many of the alternate steels might become postwar standards.

Recently the Institute completed a survey of alloy steel producers in order to determine to what extent NE steels were being made for immediate consumption. During the month of June more than 55,000 tons of NE steels will be melted. This represents about 9 per cent of the tonnage of constructional alloy steels.

During July, the survey indicates, the tonnage will approximate 25 per cent of the tonnage of such steels.

Application of NE Steels

By M. J. R. Morris[1]

Presented by J. H. Jones[2]

For the past ten or fifteen years, the number of alloy steels has increased at a staggering pace. Two years ago we in Republic had approximately 2500 different combinations on our books. The responsibility for this rests about equally with the steel producers and the users. The cost of having such a tremendous number is great when we consider lost time, off heats, added detail in handling, plus the unnecessary use of alloys.

With the advent of war, maximum utilization of steel-producing facilities became a necessity, and the special analyses to fit each shop condition, and in some cases personalities, came to an abrupt end. The reduction and unification of steel analyses were begun and have been carried through to the present time with but two objectives in mind—*first*, the establishment of the absolute minimum number of analyses, and, *second*, the selection of the alloys that will be most efficient.

The 16 original NE steel analyses resulted. These were established with rather meager information to guide the

[1] Chief Metallurgical Engineer, Central Alloy District, Republic Steel Corp., Massillon, Ohio.
[2] Central Alloy District, Republic Steel Corp., Massillon, Ohio.

decisions, and therefore it was expected that after a few months' experience, adjustment or modification would probably be necessary. However, they furnished a starting point, which obviously had to precede the experience. We can now see the need for changes, which should be made without delay.

As has been shown during the past six months, a scrap condition has developed, which demands our serious attention. Alloy steel producing plants are encountering residual chromium, nickel, and molybdenum, which may be desirable and valuable, or undesirable and harmful, depending on our ability to apply them on analyses specifying them; unless we can use the alloys we are obliged to pass them on as excessive and nonuniform residuals. The NE chromium-nickel-molybdenum steels fit the alloy mills when there is sufficient flexibility to allow intelligent utilization of scrap residuals. The application of these residuals is in accord with the alloy conservation program, while passing them on as residuals is contrary to it. The necessary capacity operation of the mill may occasionally require the use of scrap containing high alloy residuals. The customer should not consider the presence of such elements cause for rejection—to reach an agreement with the customer may cause delay; anything that causes delay or the lengthening of operations must, in these times, be analyzed and avoided, if possible.

As we develop physical property and hardenability data on the NE carburizing grades it becomes apparent that the NE 8720 will do a satisfactory job as an all-around carburizing grade. It is comparable to the 4620 grade as shown by comparison of the physical properties when pseudo-carburized as 1-in. rounds, direct oil quenched and drawn at 300-325 F.

	Tensile Strength, psi.	Yield Point, psi.	Izod Impact, ft-lb.
NE 8720 (low side)	134 000	111 000	54
4620	130 000	100 000	45

Apparently NE 8817 will, without too much hazard, replace the high alloy steels up to, but not including, SAE Nos. 3312 and 2515.

In regard to the oil-hardening grades, NE 8739 compares favorably with 4140, NE 8949 compares favorably with 4340, and NE 8749 will in ordinary sections replace our highest alloys without great hazard. For example, it gives the following hardness penetration values when oil quenched from 1550 F., with no draw:

Diameter of Bar, in.	Rockwell "C" Scale at Center of Bar
1	58
2	56
3	50
4	46
5	43

The NE steels have many desirable features—one of which is their uniformity in processing. This is due to the fact that all hardening elements are shown in the analysis and are controlled. This leads us to mention again the undesirability of passing high amounts of alloy as residuals because fluctuations in such elements will result in variations in processing characteristics.

Poorly segregated scrap, speaking in terms of chromium-nickel-molybdenum alloy steel, can be handled most advantageously in melting NE chromium-nickel-molybdenum, since all three major alloys are retained in the electric furnace and all the nickel and molybdenum are retained in the open hearth but with the loss of most of the chromium. However, if we are correctly informed, a shift of all our nickel steel to the NE grades would save about one year's nickel requirements in three years' operations. Of course, we cannot expect to accomplish a 100 per cent change to the chromium-nickel-molybdenum series, but it is not too much to expect that 50 per cent of the alloy steels used will be changed to the NE grades, resulting in a tremendous saving of nickel now available in scrap.

We feel that the present residuals maximum such as 0.20 per cent nickel, 0.25 chromium, and 0.06 molybdenum, should not be exceeded if best results are to be obtained in processing the steel.

We feel that there is a very definite need for a composition to be added to the NE list, having an analysis between residual bases just mentioned and present NE base of 0.40 per cent nickel and 0.40 chromium. We would suggest:

Manganese, per cent	Nickel, per cent	Chromium, per cent	Molybdenum, per cent
0.70–0.95	0.20–0.40	0.20–0.40	0.10–0.20

This analysis will serve in sections up to 1 in. or 1 1/2 in. on all the lower alloy applications, starting with No.

TABLE I.—NICKEL-CHROMIUM-MOLYBDENUM AND MANGANESE-MOLYBDENUM NE STEELS.

Number	Carbon, per cent	Manganese, per cent	Nickel, per cent	Chromium, per cent	Molybdenum, per cent
A 4027	0.25 to 0.30	0.70 to 0.90	.....	.....	0.20 to 0.30
A 4037	0.35 to 0.40	0.75 to 1.00	.....	.....	0.20 to 0.30
A 4063	0.60 to 0.67	0.75 to 1.00	.....	.....	0.20 to 0.30
A 4068	0.64 to 0.72	0.75 to 1.00	.....	.....	0.20 to 0.30
NE 8024	0.22 to 0.28	1.00 to 1.30	.....	.....	0.10 to 0.20
NE 8124	0.22 to 0.28	1.30 to 1.60	.....	.....	0.25 to 0.35
NE 8233	0.30 to 0.36	1.30 to 1.60	.....	.....	0.10 to 0.20
NE 8245	0.42 to 0.49	1.30 to 1.60	.....	.....	0.10 to 0.20
NE 8339	0.35 to 0.42	1.30 to 1.60	.....	.....	0.20 to 0.30
NE 8442	0.38 to 0.45	1.30 to 1.60	.....	.....	0.30 to 0.40
NE 8447	0.43 to 0.50	1.30 to 1.60	.....	.....	0.30 to 0.40
NE 8547	0.43 to 0.50	1.30 to 1.60	.....	.....	0.40 to 0.60
NE 8620	0.18 to 0.23	0.70 to 0.95	0.40 to 0.60	0.40 to 0.60	0.15 to 0.25
NE 8630	0.27 to 0.33	0.70 to 0.95	0.40 to 0.60	0.40 to 0.60	0.15 to 0.25
NE 8724	0.22 to 0.28	0.70 to 0.95	0.40 to 0.60	0.40 to 0.60	0.20 to 0.30
NE 8739	0.35 to 0.42	0.75 to 1.00	0.40 to 0.60	0.40 to 0.60	0.20 to 0.30
NE 8744	0.40 to 0.47	0.75 to 1.00	0.40 to 0.60	0.40 to 0.60	0.20 to 0.30
NE 8749	0.45 to 0.52	0.75 to 1.00	0.40 to 0.60	0.40 to 0.60	0.20 to 0.30
NE 8817	0.15 to 0.20	0.70 to 0.95	0.40 to 0.60	0.40 to 0.60	0.30 to 0.40
NE 8949	0.45 to 0.52	1.00 to 1.30	0.40 to 0.60	0.40 to 0.60	0.30 to 0.40

All of the above steels contain 0.20–0.35 silicon and 0.040 maximum each sulfur and phosphorus.

4023 through Nos. 5120, 4120, 3120, and 4620. A similar oil-hardening analysis will find a similar field in replacing the 0.40 per cent carbon steels of the types just mentioned.

The effect of small amounts of chromium, nickel, and molybdenum are greater than expected, especially by those accustomed to working with higher additions of one of these elements. For example, an analysis having the composition 0.23 carbon, 0.82 manganese, 0.23 silicon, 0.26 nickel, 0.34 chromium, and 0.13 molybdenum gave hardenability within one point Rockwell "C" of that obtained from No. 2320 in sections equivalent to a 4-in. round. For ordinary applications we would not hesitate to use such a steel to replace a higher alloy steel.

The NE steels are being applied in about every application where structural alloy steel has been used. The suggested 0.20–0.40 nickel, 0.20–0.40 chromium and 0.10–0.20 molybdenum is going into truck gears having sections not over 3/4 in. The NE 8620 (high side) or NE 8720 is being applied over a wide range of parts and sizes replacing Nos. 4620, 6120, 2320, 2515, and even 4320 in light sections. NE 8817 is being used to replace the higher alloys, such as Nos. 2515, 4320, 4820, and to some extent 3312, in light sections.

The oil-hardening grades cover about the same field of SAE analyses. NE 8739 is becoming a popular gear steel, because of exceptional machining qualities, coupled with maximum uniformity from heat to heat, and the very minimum distortion in heat treating. We expect to have many favorable reports, such as this, on the NE chromium-nickel-molybdenum steels.

Low-temperature Charpy impact values are favorable. The NE 8739, 8749, and 8949 compare well with our best alloys at −27 and −65 F.

To complete the NE chromium-nickel-molybdenum carburizing series, we need only three grades, as follows:

Carbon, per cent	Manganese, per cent	Chrome, per cent	Nickel, per cent	Molybdenum, per cent
0.19–0.25	0.70–0.95	0.20–0.40	0.20–0.40	0.10–0.20
0.18–0.23	0.70–0.95	0.40–0.60	0.40–0.60	0.20–0.30
0.15–0.20	0.70–0.95	0.40–0.60	0.40–0.60	0.30–0.40

The suggested lower chromium-nickel-molybdenum NE steel will replace such alloy steels as 4023, 5120, 4120, and 3120, and in some cases higher alloys depending on section and application. The impression should not be gained that the manganese-molybdenum NE (A 4027, A 4037, and A 4068, etc.) or other noncritical steels are not to be used, but if conditions beyond control of steel producers such as the alloys contained in scrap definitely favor the melting of chromium-nickel-molybdenum types, as is the case today, then such conditions must be recognized and given proper consideration. Otherwise, the alloy conservation program will fall short of its intended goal.

Numerous A.S.T.M Standards Approved by the American Standards Association

THERE IS PRESENTED below a list of the many A.S.T.M. specifications and methods of test that have been accorded approval as American standard by the American Standards Association during the past year. In this list we have not only indicated the date of approval by A.S.A., but for convenience of reference the A.S.T.M. serial designations and the A.S.A. numbers as well. In addition to these approvals, a number of standards that were revised by A.S.T.M. and which had been accorded earlier approval by A.S.A. have been reapproved by that association in their revised form. The number of A.S.T.M. specifications and methods of tests which have been approved as American standard as of May 1 totals 180 which includes those listed below.

The Society as one of the five founder organizations of the A.S.A. (then the American Engineering Standards Committee), has participated in the activities since 1918.

In submitting its standards to the A.S.A. for approval, the Society utilizes either of two methods. The procedure that is particularly appropriate so far as A.S.T.M. standards are concerned is the so-called Existing Standards Procedure. Under this an existing standard can be submitted to the A.S.A. and if it can be demonstrated that the standard in question represents a consensus of those interested, that it represents existing practice, and that it has received recognition and utilization in the field, the A.S.A. is prepared to accept the standard and approve it as American standard. As might be expected, the A.S.T.M. standards can very readily be shown to meet these criteria. In all instances when A.S.T.M. standards are submitted under the existing standards procedure, the Society asks for recognition as proprietary sponsor so that any future revisions that may be made in these specifications may be submitted to the A.S.A. through the proprietary sponsorship method.

In some instances, however, the Sectional Committee Procedure is more appropriate for the submittal of A.S.T.M. standards to the A.S.A., particularly in cases where a number of other organizations have a direct interest in the particular standard that has been adopted by the A.S.T.M. For example, those standards in the following list relating to petroleum products and lubricants have been submitted to the A.S.A. through Sectional Committee Z11 and certain others on electrical insulating materials through Sectional Committee C59.

It is expected that additional approvals will be accorded to A.S.T.M. standards during the next few months; several submittals have already been made and some few additional ones will be referred to the A.S.A. shortly. In view of the need under present conditions to standardize wherever possible, it is particularly appropriate that A.S.T.M. standards, recognized by industry as American standards in fact, be so designated and listed by the American Standards Association.

	A.S.T.M.	A.S.A.
STEEL—APRIL 10, 1942		
Specifications for:		
Low Tensile Strength Carbon-Steel Plates of Structural Quality for Welding	A 78–40	G40.1—1942
Structural Silicon Steel	A 94–39	G41.1—1942
High-Strength Structural Rivet Steel	A 195–41	G42.1—1942
Axle-Steel Bars for Concrete Reinforcement	A 160–39	G43.1—1942
Fabricated Steel Bar or Rod Mats for Concrete Reinforcement	A 184–37	G44.1—1942
Welded Steel Wire Fabric for Concrete Reinforcement	A 185–37	G45.1—1942
CAST IRON—APRIL 10, 1942		
Specifications for:		
Gray Iron Castings	A 48–41	G25.1—1942
Cast-Iron Culvert Pipe	A 142–38	G26.1—1942
Lightweight and Thin-Sectioned Gray-Iron Castings	A 190–40	G27.1—1942

(*Continued on next page*)

GYPSUM—JULY 14, 1941

Specifications for:		
Calcined Gypsum for Dental Plasters	C 72 – 40	A65.1—1941
Keene's Cement	C 61 – 40	A66.1—1941
Gypsum Lath	C 37 – 40	A67.1—1941
Gypsum Sheathing Board	C 79 – 34	A68.1—1941
Gypsum Wall Board	C 36 – 34	A69.1—1941
Methods of:		
Testing Gypsum and Gypsum Products	C 26 – 40	A70.1—1941

MANUFACTURED MASONRY UNITS—JANUARY 14, 1942

Specifications for:		
Concrete Masonry Units for Construction of Catch Basins and Manholes	C 139 – 39	A73.1—1942

APRIL 10, 1942

Structural Clay Load-Bearing Wall Tile	C 34 – 41	A74.1—1942
Concrete Building Brick	C 55 – 37	A75.1—1942
Structural Clay Non-Load-Bearing Tile	C 56 – 41	A76.1—1942
Structural Clay Floor Tile	C 57 – 39	A77.1—1942
Sand-Lime Building Brick	C 73 – 39	A78.1—1942
Hollow Load-Bearing Concrete Masonry Units	C 90 – 39	A79.1—1942
Hollow Non-Load-Bearing Concrete Masonry Units	C 129 – 39	A80.1—1942
Solid Load-Bearing Concrete Masonry Units	C 145 – 40	A81.1—1942
Methods of:		
Sampling and Testing Brick	C 67 – 41	A82.1—1942
Sampling and Testing Brick	C 112 – 36	A83.1—1942
Sampling and Testing Concrete Masonry Units	C 140 – 39	A84.1—1942

PAINT, VARNISH, LACQUER, AND RELATED PRODUCTS—OCTOBER 16, 1941

Specifications for:		
Basic Sulfate White Lead	D 82 – 38	K47—1941
Blue Lead; Basic Sulfate	D 405 – 41	K48—1941
C. P. Para Red Toner	D 475 – 41	K49—1941
C. P. Zinc Yellow (Zinc Chromate)	D 478 – 41	K50—1941
Methods of Test for:		
Alkalinity or Acidity of Pigments	D 278 – 31	K51—1941
Bleeding of Pigments	D 279 – 31	K52—1941
Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments	D 280 – 33	K53—1941
Oil Absorption in Pigments	D 281 – 31	K54—1941
Acetone Extract in Dry Lampblack and Dry Bone Black	D 305 – 31	K55—1941
Tinting Strength of White Pigments	D 332 – 36	K56—1941
Mass Color and Tinting Strength of Color Pigments	D 387 – 36	K57—1941
Methods of Chemical Analysis of:		
Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments, and Chrome Green	D 126 – 36	K58—1941
Dry Mercuric Oxide	D 284 – 33	K59—1941

PETROLEUM PRODUCTS AND LUBRICANTS—OCTOBER 16, 1941

Methods of:		
Conversion of Kinematic Viscosity to Saybolt Universal Viscosity	D 446 – 39	Z11.46—1941
Test for Distillation of Plant Spray Oils	D 447 – 41	Z11.43—1941
Vapor Pressure of Petroleum Products (Reid Method)	D 323 – 41	Z11.44—1941
Calculating Viscosity Index	D 567 – 41	Z11.45—1941

RUBBER PRODUCTS—MARCH 18, 1942

Specifications for:		
Electrical Gloves (Voltage Rating of Glove—3000 volts)	D 120 – 40	C59.12—1942

JANUARY 14, 1942

Methods of:		
Sample Preparation for Physical Testing of Rubber Products	D 15 – 41	J1.1—1942
Tension Testing of Vulcanized Rubber	D 412 – 41	J2.1—1942
Test for Adhesion of Vulcanized Rubber (Friction Test)	D 413 – 39	J3.1—1942
Test for Accelerated Aging of Vulcanized Rubber by the Oxygen-Pressure Method	D 572 – 41	J4.1—1942
Test for Accelerated Aging of Vulcanized Rubber by the Oven Method	D 573 – 41	J5.1—1942

ELECTRICAL INSULATING MATERIALS—OCTOBER 14, 1941

Methods of:		
Test for Impact Resistance of Electrical Insulating Materials	D 256 – 38	C59.11—1941

Navy Needs Binoculars

"IT IS OF VITAL importance that the Navy obtain as many pairs of binoculars suitable for sea use as possible, at once," so starts a communication from the Fourth Naval District. We have been asked to bring this matter to the attention of our members, and a few salient facts are given here. Because the manufacture of binoculars has been centered abroad, the United States does not have the facilities to produce these precision instruments here at the rate they are needed. So far some 1500 binoculars have been loaned the Navy but a great many more are needed. The only acceptable ones are 6 by 30's and 7 by 50's made by Bausch and Lomb or Zeiss. Binoculars of less than six power have proved of little value at sea. High-powered ones with front lenses less than 30 millimeters wide shut out too much of the light necessary to good vision, especially at night or in hazy weather. The Navy insists on these two standard types because of difficulty in obtaining parts and personnel to keep a wide variety in good condition.

Persons whose binoculars meet requirements and who wish to lend them to the Navy are requested to tag them with the owner's name and address, pack them carefully, and ship to: The Naval Observatory, Washington, D. C. If your binoculars are not in good working order, or if they are approximately but not exactly up to Navy specifications, do not ship them. Instead, write a letter to the Naval Observatory, giving manufacture, type, power, and objective opening (front lens measurement) of binoculars and stating what repairs, if any, are needed to put them in good condition. They will be called for if and when needed.

As the Navy is not authorized to accept gifts or free loans, all binoculars it accepts will be "purchased" for $1.00 each. If still in use at the end of the war, they will be returned to the owners.

All binoculars accepted are engraved with the donor's name and a special serial number to identify them. They are then issued immediately to naval vessels and the commanding officers are requested to notify the donors of the names of the ships aboard which their binoculars are "serving in the Navy."

ERRATA

SINCE THE PUBLICATION of the May ASTM BULLETIN attention has been called to an arithmetical error which appears in Fig. 3 of the paper, "The Electron Microscope and Its Uses," by R. Bowling Barnes and Charles J. Burton, May ASTM BULLETIN, No. 116, pages 34 to 41. The following explanation, therefore, should be noted:

1. In Fig. 3, p. 35, the constant K in Abbé's Law is equal to 1.0 for axial illumination (parallel light incident upon the object), and is equal to 0.5 for oblique illumination. In actual practice, whenever a condenser is used, the illumination is very much closer to oblique than to axial. Therefore the value of K varies between 1.0 and 0.5 and should usually be thought of as being very close to 0.5.

2. The numerical calculations shown in Fig. 3 for the wave length of the electron and the resolving power of the electron microscope should read as follows:

$$\lambda = \sqrt{\frac{150}{V}} \times 10^{-4} \text{ microns}$$

$$= \sqrt{\frac{150}{55{,}000}} \times 10^{-4} = 0.00005 \text{ micron}$$

$$R_{\text{Abbé}} \cong \frac{\lambda}{2\ N.A.} = \frac{5 \times 10^{-5}}{2 \times 2 \times 10^{-2}}$$

$$\cong 0.0012 \text{ micron}$$

The absolute value of the numerical aperture for any particular electron microscope is difficult to determine. Ruska has shown that the optimum numerical aperture, corresponding to the largest diameter magnetic lens which can be employed successfully to form a satisfactory image, is 0.02. If this optimum value obtains, the magnitude of the diffraction effects in the image equals that of the lens aberrations. In actual practice the effective Numerical Aperature is probably less than this value.

[A further discussion of resolving power which appears in the second column of page 35 will be published in a later issue of the ASTM BULLETIN.—Ed.]

Discussion of the Effect of Minor Alloying Elements on Aluminum Casting Alloys

By W. Bonsack[1]

EDITOR'S NOTE.—This outstanding technical contribution based on exhaustive work by the National Smelting Co. should be of interest to every technologist concerned with die casting and foundry problems in the fields covered. In the opinion of leading authorities the paper contributes much to our knowledge of the actions and effect of so-called impurities in the alloys studied.

MOST ALL commercial metals contain metallic and nonmetallic elements which, for one reason or another, cannot be removed without great expense. These elements are generally classified as "impurities." It is not always known whether these impurities are harmful or whether they are useful. The lack of such knowledge implies a certain right to call a small quantity of such elements an impurity or undesirable ingredient.

Aluminum and its alloys are no exception to the rule. It is expensive to purify aluminum to a content of 99.90 per cent or higher. The purest commercial aluminum still contains a total of about 0.2 or 0.3 per cent of such elements as iron and silicon, and others such as sodium, titanium, manganese, zinc, and gallium in much smaller amounts. Where aluminum is combined with other commercial metals to form alloys, other "impurity elements" are carried into the alloys. It is often noticeable that copper additions also add a small amount of silver to the resultant aluminum-copper alloy. The addition of silicon introduces iron and may also introduce calcium into the alloy.

Melting the alloys also often leads to absorption of other elements dissolved from the melting vessels and furnace tools. Even under the strictest methods of alloying and melting, additions of other metals occur. The more aluminum is remelted, the greater is the accumulation of so-called metallic impurities. During remelting of scrap metals, the introduction of other elements is often unavoidable. For example, it is impossible to separate mixtures of borings of several aluminum alloys, mixed sheet scrap, or other similar materials. Thus, elements such as copper, zinc, manganese, magnesium, iron, chromium, nickel, silicon, lead, tin, bismuth, titanium, and others find their way into aluminum alloys. If sodium and calcium are added to the list, then there are fourteen common elements in aluminum alloys which may be desired alloying elements, innocuous, or harmful.

Many other metals also accumulate impurities; but in some cases it is possible to remove them by relatively simple operations, either by furnacing, distilling, or electrolytically. Aluminum can be purified electrolytically, but the cost is too great to make it commercially practical for aluminum and aluminum alloys.

Since these unwanted minor alloying elements cannot be removed from aluminum, it becomes necessary to use these alloys to the best advantage, especially so under the present existing shortage of aluminum. This is, however, not a new situation for the foundry industry. Remelted aluminum has been successfully used for a long time, and that this material is usable has been demonstrated by the enormous growth of the secondary aluminum industry.

The full use of remelted aluminum alloys, however, is limited by existing specifications. These specifications were drawn in such a limiting fashion because the complete information on the effect of these elements was not generally known. Before the war there was plenty of pure aluminum available, and the solution of this problem was not so vital. The war, however, has changed the situation. The main trend now seems to be to determine how many and what amounts of these minor elements can be present without affecting the properties of aluminum alloys adversely.

The whole problem resolves itself into the following:

1. What is an "impurity" and when is a minor alloying element an impurity?
2. What effect has this "impurity" on the physical properties?
3. What are the usable limits of this "impurity?"

An attempt was made to answer these questions by an extensive search through the world's leading literature, and surprisingly meager information was found. Many of the articles studied have little value for our purpose because the data were gathered from alloys made chiefly for research purposes and laboratory tested from highly theoretical rather than practical aspects, or on worked material such as sheet, which is not discussed here. When the problem of corrosion resistance is considered, the greatest amount of information available has little direct bearing on the practical use of the alloys, and the investigators usually summarize their work with such broad generalizations that a misleading impression can readily be gained by a hurried reader.

Appended to this paper is a bibliography of the literature, together with references[2] covered during this work; but the author will try to attack the problem from a more practical point of view.

Aluminum alloys are sand cast, chill cast, die cast, or worked by forging, rolling, or drawing. In this short discussion we will limit ourselves to the aluminum casting alloys used in the first three methods of fabrication. Furthermore, to obtain a basis for the discussion of the effect of minor alloying elements on aluminum alloys, only the casting alloys specified by the A.S.T.M. will be considered.

Table I represents a comparison of A.S.T.M. alloys as used for sand, permanent mold, and die castings. It is noted that several of the alloys are used for more than one

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Chief Metallurgist, In Charge of Research Laboratories, The National Smelting Co., Cleveland, Ohio.

[2] These references were gathered with the aid of D. Basch, J. G. G. Frost, and W. Rowe.

TABLE I.—ALUMINUM-COPPER AND ALUMINUM-SILICON ALLOYS.

Group	A.S.T.M. Specifications	Alloy	Cast[d]	Chemical Analysis, per cent											
				Copper	Iron	Silicon	Magnesium	Manganese	Zinc	Nickel	Tin	Chromium	Titanium	Others	Aluminum
1	B 26 – 41 T[a]	C	S	7.0 ± 1.0	1.5	2.0 ± 1.0	0.05	0.3	2.2	....	....	....	....	1.0	remainder
	B 26 – 41 T	CC	S	7.7 + 0.8 − 0.7	1.0 + 0.4 − 0.2	1.25 ± 0.25	0.05	0.3	0.2	....	....	....	....	0.3	remainder
	B 108 – 41 T[b]	2	P	7.0 ± 1.0	1.4	4.0	0.1	0.3	2.5	....	....	....	....	1.0	remainder
	B 85 – 39 T[c]	XII	D	6.0 to 8.0	2.3	3.5	0.1	0.3	1.8	0.5	0.3	....	....	0.3	91.00
2	B 26 – 41 T	F	S	10.0 ± 0.75	1.5	Fe + Si 2.0 max.	0.25 ± 0.1	0.3	0.2	....	....	....	....	0.3	remainder
	B 108 – 41 T	4	P	10.0 ± 0.75	1.5	1.0	0.25 ± 0.1	0.3	0.4	0.3	....	....	....	0.5	remainder
	B 108 – 41 T	5	P	10.0 ± 1.0	1.2	4.0 ± 0.5	0.25 ± 0.1	0.3	0.5	....	....	....	....	0.5	remainder
3	B 26 – 41 T	G	S	4.5 ± 0.5	1.0	1.2	0.03	0.05	0.05	....	....	....	0.2	0.05 each	remainder
	B 26 – 41 T	GG	S	4.5 ± 0.5	1.2	1.2	0.1	0.3	0.2	....	....	....	0.2	0.2	remainder
	B 108 – 41 T	1A	P	4.5 ± 0.5	1.0	2.5 ± 0.5	0.05	0.3	0.2	....	....	....	....	0.3	remainder
	B 108 – 41 T	3	P	4.5 ± 0.5	1.0	5.5 ± 0.5	0.1	0.3	0.5	....	....	....	....	0.5	remainder
4	B 85 – 39 T	VII	D	3.5 to 4.5	2.3	4.5 to 5.5	0.1	0.3	1.0	0.5	0.1	....	....	0.2	91.00
	B 85 – 39 T	IX	D	3.5 to 4.5	1.8	1.0 to 2.5	0.05	0.3	0.8	3.5 to 4.5	0.1	....	....	0.2	90.25
	B 85 – 39 T	VIII	D	1.0 to 2.0	2.0	0.5 to 1.0	0.1	0.3	0.5	1.75 to 2.5	0.1	....	....	0.2	95.50
	B 26 – 41 T	H	S	4.0 ± 0.5	1.0	0.7	1.5 ± 0.3	0.3	0.1	2.0 ± 0.3	....	....	....	0.3	remainder
	B 108 – 41 T	11	P	4.0 ± 0.5	1.0	0.7	1.5 ± 0.3	0.3	0.1	2.0 ± 0.3	....	....	....	0.3	remainder
5	B 26 – 41 T	J	S	0.4	0.8	5.0 + 1.0 − 0.5	0.05	0.3	0.2	....	....	....	0.2	0.3	remainder
	B 26 – 41 T	JJ	S	0.1	0.8	5.0 + 1.0 − 0.5	0.05	0.05	0.05	....	....	....	0.2	0.05 each	remainder
	B 108 – 41 T	9	P	0.4	0.8	5.0 + 1.0 − 0.5	0.05	0.3	0.3	....	....	....	....	0.3	remainder
	B 108 – 41 T	9A	P	0.1	0.8	5.0 + 1.0 − 0.5	0.05	0.05	0.05	....	....	....	....	0.05 each	remainder
	B 85 – 39 T	IV	D	0.6	2.0	4.5 to 6.0	0.1	0.3	0.5	0.5	0.1	....	....	0.2	95.00
6	B 26 – 41 T	K	S	0.15	0.8	12.5 ± 0.5	0.05	0.2	0.1	....	....	....	....	0.2	remainder
	B 108 – 41 T	8	P	0.3	0.8	11.0 ± 1.0	0.05	0.5	0.3	....	....	....	....	0.5	remainder
	B 85 – 39 T	V	D	0.6	2.0	11.0 to 13.0	0.1	0.3	0.5	0.5	0.1	....	....	0.2	88.00
7	B 26 – 41 T	N	S	1.25 ± 0.25	0.5	5.0 ± 0	0.5 ± 0.1	0.1	0.05	....	....	....	0.2	0.2	remainder
	B 85 – 39 T	VI	D	1.5 to 2.5	2.5	2.5 to 3.5	0.1	0.3	0.8	0.5	0.1	....	....	0.2	95.00
	B 85 – 39 T	XI	D	1.0 to 3.0	2.0	7.0 to 9.0	0.1	0.3	0.5	0.5	0.1	....	....	0.2	90.00
	B 26 – 41 T	M	S	0.2	0.5	7.0 ± 0.5	0.3 ± 0.1	....	0.05	....	....	....	0.2	0.05 each	remainder
	B 108 – 41 T	10	P	0.2	0.5	7.0 ± 0.5	0.3 ± 0.1	0.05	0.05	....	....	....	....	0.05 each	remainder
8	B 26 – 41 T	L	S	0.1	0.4	0.25	3.75 ± 0.5	0.6	0.05	....	....	....	0.2	0.05 each	remainder
	B 26 – 41 T	O	S	0.2	1.0	0.6	0.5 ± 0.1	....	5.0 + 0.7 − 0.2	....	....	0.5 ± 0.1	0.2 ± 0.1	0.05 each	remainder
	B 108 – 41 T	6	P	1.0 ± 0.5	1.3	12.0 ± 1.0	1.0 ± 0.25	0.05	0.1	2.5 ± 0.5	....	....	....	0.2	remainder
	B 108 – 41 T	7	P	1.5 ± 0.5	0.9	12.25 ± 0.75	0.55 ± 0.15	0.75 ± 0.15	0.4	0.05	....	....	....	0.3	remainder

[a] Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 41 T), 1941 Supplement to Book of A.S.T.M. Standards, Part I, p. 314.
[b] Tentative Specifications for Aluminum-Base Alloy Permanent Mold Casting (B 108 – 41 T), 1941 Supplement to Book of A.S.T.M. Standards, Part I, p. 322.
[c] Tentative Specifications for Aluminum-Base Alloy Die Casting (B 85 – 39 T), 1939 Book of A.S.T.M. Standards, Part I, p. 1147.
[d] S = sand cast; P = permanent mold; D = die cast.

TABLE II.—ALUMINUM-COPPER AND ALUMINUM-SILICON ALLOYS.

Group	A.S.T.M. Specifications	Alloy	Cast	As Cast				Heat Treatment No. 1		Heat Treatment No. 2		Heat Treatment No. 3		Charpy Impact, ft-lb.
				Tensile Strength, psi.		Elongation in 2 in., per cent		Tensile Strength	Elongation	Tensile Strength	Elongation	Tensile Strength	Elongation	
				Minimum	Typical	Minimum	Typical	Minimum	Minimum	Minimum	Minimum	Minimum	Minimum	
1	B 26 – 41 T	C	S	19 000	....	1.0	...	....	...	....	...	....	...	...
	B 26 – 41 T	CC	S	19 000	....	1.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	2	P	23 000	....	...	...	....	...	....	...	....	...	...
	B 85 – 39 T	XII	D	....	34 000	...	1.6	....	...	....	...	....	...	3.2
2	B 26 – 41 T	F	S	19 000	....	...	...	....	...	....	...	....	...	...
	B 108 – 41 T	4	P	....	....	...	...	28 000	...	38 000	...	....	...	...
	B 108 – 41 T	5	P	26 000	....	...	...	....	...	....	...	....	...	...
3	B 26 – 41 T	G	S	....	....	...	...	29 000	6.0	32 000	3.0	36 000	...	...
	B 26 – 41 T	GG	S	....	....	...	...	....	...	....	...	36 000	...	...
	B 108 – 41 T	1A	P	....	....	...	...	33 000	4.5	42 000	1.0	....	...	...
	B 108 – 41 T	3	P	23 000	....	...	...	....	...	....	...	....	...	...
4	B 85 – 39 T	VII	D	....	32 000	...	2.0	....	...	....	...	....	...	2.5
	B 85 – 39 T	IX	D	....	31 000	...	1.5	....	...	....	...	....	...	2.0
	B 85 – 39 T	VIII	D	....	29 000	...	4.0	....	...	....	...	....	...	4.5
	B 26 – 41 T	H	S	....	....	...	...	32 000	...	....	...	....	...	...
	B 108 – 41 T	11	P	....	....	....	...	33 000	...	40 000	...	....	...	...
5	B 26 – 41 T	J	S	17 000	....	3.0	...	....	...	....	...	....	...	...
	B 26 – 41 T	JJ	S	17 000	....	3.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	9	P	21 000	....	2.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	9A	P	21 000	....	2.5	...	....	...	....	...	....	...	...
	B 85 – 39 T	IV	D	....	29 000	...	3.5	....	...	....	...	....	...	4.5
6	B 26 – 41 T	K	S	24 000	....	5.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	8	P	27 000	....	3.0	...	....	...	....	...	....	...	...
	B 85 – 39 T	V	D	....	33 000	...	1.5	....	...	....	...	....	...	2.0
7	B 26 – 41 T	N	S	....	....	...	...	....	...	32 000	2.0	25 000	1.0	...
	B 85 – 39 T	VI	D	....	30 000	...	3.5	....	...	....	...	....	...	5.0
	B 85 – 39 T	XI	D	....	32 000	...	1.7	....	...	....	...	....	...	3.0
	B 26 – 41 T	M	S	....	....	...	...	26 000	5.0	30 000	3.0	....	...	...
	B 108 – 41 T	10	P	....	....	...	...	28 000	5.0	30 000	3.0	....	...	...
8	B 26 – 41 T	L	S	22 000	....	6.0	...	....	...	....	...	....	...	...
	B 26 – 41 T	O	S	30 000	....	3.0 (aged)	...	....	...	....	...	....	...	...
	B 108 – 41 T	6	P	....	....	....	...	28 000	...	36 000	...	....	...	...
	B 108 – 41 T	7	P	....	....	....	...	32 000	...	36 000	...	....	...	...

method of casting. Several others are modified slightly to better suit a particular casting process. In this table all alloys are grouped together which are basically the same. In this manner two main groups of alloys can be distinguished: the aluminum-copper alloys and their derivatives, and the silicon alloys and their variations. In the copper alloy group, 1.5, 4.5, 7.5, and 10 per cent copper alloys are the subdivisions; in the silicon alloy group, the subdivisions are 3, 5, 7.5, and 12 per cent silicon. Table II presents the typical and minimum properties of these alloys as the case may be.

In order to discuss the limits of impurities or minor alloying elements of the above alloys, one must decide the angle of attack. The logical way is to consider the influence of the different minor alloying elements (1) in respect to the physical properties, and (2) in respect to the corrosion properties. The physical properties should be relatively easy to analyze, while the corrosion resistance is very hard to prove or disprove, since no standard tests are available which repeatedly give the same answer; and the few test methods which give information are of value for comparison in theoretical studies of alloys, but are not a reliable guide for actual service requirements.

Furthermore, it is the present practice to use protective coatings, such as anodizing or painting, on aluminum castings that are subjected to corrosion. Although the problem of corrosion is interesting, it is not nearly so important as the physical properties which can be accurately measured, and which give numerical data directly usable for designing of castings, machines, apparatus, and the like. It is, therefore, more important to be well informed regarding the effect of these minor alloying elements on the castability, machinability, tensile strength, yield strength, proportional limit, elongation, impact strength, heat treatability, and stability at elevated, subnormal, and room temperatures.

It should be noted that in the above grouping of properties, castability is listed first. Casting alloys should cast easily in order to be free of defects such as shrinkage-porosity, cracks, and so-called cold shut or welds which are often caused by alloys of low fluidity, and free of dross inclusions which might be caused by readily oxidizing alloying elements. An aluminum alloy which is difficult to cast and from which only occasionally sound castings are obtained will not produce properties comparable to those found in a relatively simple test bar casting from the same alloy. A poor casting, made of a high-strength difficult-to-cast alloy, is less desirable than a sound casting made from a somewhat less strong, but easy-to-cast alloy.

Machinability is next in importance. Castings hard to machine are not desirable for several reasons. Machining cost is high; tool life is low; it might not be possible to obtain a finish which will guarantee good bearing; or, in stressed members, drag marks of the tools will cause notch effects which might lead to weakness of the casting, especially when it is subjected to vibrational stresses.

PART I—ALUMINUM-COPPER, ALUMINUM-COPPER-SILICON, AND ALUMINUM-COPPER-NICKEL ALLOYS

Group 1: 8 per cent Copper Alloy

With these considerations in mind, the discussion of the A.S.T.M. alloys can be opened with the alloys C, CC, 2, and XII, which are all the old 8 per cent copper type, generally known as No. 12 alloy. The original composition was 8 per cent copper and 92 per cent aluminum, the only impurities being a little iron and silicon. This alloy is hard to cast—its fluidity or mold filling ability is not very good, and it is also somewhat hotshort. The addition of more silicon improves the castability of the alloy. It should be noted that the chill-cast specification allows more silicon than the sand-cast specification because these two mentioned properties—fluidity and hot shortness—need to be well controlled in chill castings (*93*).[3] The two elements copper and silicon are desired as indicated by the range given.[4] All other elements, therefore, are to be considered "impurities."

The most common undesired element in all aluminum alloys, and, of course, also in the above alloys, is *iron*. It originates from the aluminum ore, and is further increased by dissolution of melting vessels and tools. Iron, with aluminum and the other alloying elements, forms complex intermetallic compounds. These compounds have, in general, very low solid solubility in aluminum, and crystallize either in needle and plate form, or in skeleton dendrites (a form known as "chinese script"), or both. These compounds, like most intermetallic compounds, are brittle and reduce the ductility of the aluminum-copper-silicon alloy, the reduction in ductility depending on the amount present and on the size and types of the crystals.

Since the size and form of these crystals depend mainly on the chill obtained during solidification, the alloys which are subject to the most chill during casting can also contain the largest amount of iron. Therefore, the die-cast alloy No. XII permits iron up to 2.3 per cent. In permanent mold castings, the same amount of ductility can be obtained with 1.6 per cent iron. However, the specification allows only 1.4 per cent maximum. Sand castings cool relatively slowly, and when iron is present in amounts of 1.5 per cent, relatively low ductility will result, and also low strength. For good commercial sand castings where a fairly good ductility is desired, the iron content should not be over 1.3 per cent.

Experience has shown that to obtain good usable properties in sand castings, the iron content should be somewhat lower than the given limits. Iron has, in spite of the mentioned disadvantages, some good points. It decreases the hot shortness of the alloys, improves the tensile strength, yield strength, and hardness slightly, and preserves strength at elevated temperature. In combination with silicon in aluminum-copper alloys it has been found to be desirable, as shown in alloy CC. However, this is only true when the silicon content is low—less than 1.5 per cent. If the silicon content is higher, the proportion of iron to silicon is no longer important, since the higher silicon content causes the same improvement in the alloys as iron does in low silicon containing copper-aluminum alloys. However, too high an iron content in combination with high silicon is also bad. Therefore, the iron content should be kept within the limits given

[3] The italic numbers in parentheses refer to the reports and papers appearing in the Bibliography appended to this paper.

[4] The desirable elements in all alloys are indicated by ranges of percentages.

above to avoid poor castability, coarse crystal structure, shrinkage cracks, porosity, and brittleness.

Magnesium is the next element in this series of alloys, and is limited to a maximum of 0.1 per cent. There is, of course, a very good reason for this. Magnesium combines with the silicon of the alloys to form an intermetallic compound Mg_2Si, which is relatively soluble in the solid aluminum. The solubility increases with increasing temperature, and it amounts to about 1.75 per cent at the eutectic temperature. By rapid chilling, some of this compound is kept in solid solution. This solid solution, however, represents an unstable condition of supersaturation. The alloy tends to revert to the stable state by precipitating the Mg_2Si in an ultra-fine dispersed form. This precipitation is accompanied by a general rapid increase in hardness, strength, proportional limit, yield strength, and an equally drastic decrease in elongation and general ductility. The more rapid the chilling of the alloy, the more Mg_2Si will be kept in solution, and the greater the hardening effect.

When the magnesium content is kept within the range of solid solution at room temperature, the hardening effect is low. It has been found that 0.05 per cent is a safe limit, although even 0.07 per cent does not cause brittleness. The embrittling effect of magnesium can be counteracted by a suitable low temperature aging treatment, such as heating a few hours at 300 C. The hardening effect is the main reason for holding magnesium to such low limits. There are other reasons which might make this element desirable or undesirable depending on the use of the casting. It is said that magnesium makes the alloy sluggish—that is, harder to cast, and also hot short; however, in these low ranges it is without noticeable influence. The fact that magnesium hardens the aluminum crystal by its ability to go into solid solution even in small amounts, improves the machinability of the alloy considerably.

Manganese is an element which has many desirable functions in aluminum alloys, particularly in aluminum-copper alloys. Manganese forms simple and complex compounds with aluminum which have relatively low solid solubility in aluminum. It is a mild "hardener," increases the strength, proportional limit, yield strength, and hardness slightly with increasing amounts, and reduces the ductility gradually. Its greatest advantages are its effect on the iron-aluminum complex, which it is said changes from the harmful needle or plate type into a less embrittling form; it decreases hot shortness; and improves the properties of the alloys at elevated temperature. It is said that it reduces the castability of the alloy to some extent. However, not much difference will be found in the alloys under consideration even where manganese is present as high as 0.5 per cent (the present specification limits this element to 0.3 per cent). It also counteracts somewhat the hardening which is caused by small amounts of magnesium. Machining properties are improved by the presence of this element (*72*).

Zinc is one element which is permitted to be present in these four alloys to a considerable extent—as high as 2.5 per cent. Zinc was originally carried into the alloy by the old aluminum-zinc-copper alloy which contained up to 30 per cent zinc. A few pounds of this high zinc scrap, zinc castings, or borings contaminated with zinc or brass, added accidentally to the 8 per cent copper alloys causes considerable enrichment in the zinc content.

The solid solubility of zinc in aluminum is about 17 per cent at room temperature. Therefore, its hardening effect in amounts as low as 2.5 per cent is mild. It increases tensile strength, yield strength, proportional limit, and hardness somewhat, without decreasing the ductility noticeably. It improves the machinability of the alloys (*150*), has little effect on fluidity, and in amounts up to 2.5 per cent is said to improve castability. It is said to increase the hot shortness of the alloys, although the alloy specification for permanent-mold castings allows more zinc than for sand castings which is really contrary to what one would expect, since hot shortness is a more serious difficulty to overcome in an iron mold than in a sand mold. Die casters, however, allow less zinc than either sand or permanent mold casters. It is probably not for the reason of hot shortness, but rather to keep the total amount of alloying elements low. Zinc has been used in these alloys in even higher amounts—as high as 5 per cent—and still gave usable alloys.

The "other elements" in the alloys are limited to 1 per cent total amount. These elements are nickel, chromium, titanium, tin, lead, bismuth, and others mentioned before. Of these, nickel, tin, and lead are the most frequently found. Only in the die-casting alloy No. XII are nickel and tin specifically mentioned and limited to 0.5 per cent and 0.3 per cent, respectively.

Nickel forms an intermediary compound of Al_3Ni with aluminum, and in aluminum-copper-iron alloy forms complex compounds. Nickel hardens and strengthens, but also reduces ductility slightly—about on the order of copper and manganese. It is slightly soluble in aluminum at room temperature. It is said to decrease hot shortness and helps to retain strength and hardness at elevated temperatures (*122*). It improves machinability due to its hardening effect. It is said to improve the color and to aid in the polishing of the casting.

Tin does not form intermetallic compounds with aluminum. It is not soluble in it, but forms a simple eutectic with it. Its low melting point tends to increase hot shortness; therefore, its amount must be limited to about 0.5 per cent or even 0.3 per cent or less where hot shortness is a definite problem. It improves machinability considerably. It does not improve any of the other mentioned properties to any noticeable extent. Tin has been used up to 2 per cent in die castings and 5 per cent in sand castings. To some extent the hot shortness due to tin can be compensated for with silicon.

Lead is also very often found in these alloys. Since lead does not mix with aluminum, it will separate from it when it is present in larger amounts. In small amounts of less than 0.5 per cent, it is usually found in the grain boundaries as small globules. Its low melting point, especially when in combination with tin, causes hot shortness; and it has been found that about 0.7 per cent of lead plus tin are the maximum allowable limits for sand and permanent mold castings. It does not influence fluidity nor the physical properties such as tensile strength, proportional limit, elongation, etc., to any detrimental extent, when present in the above limits. However, it improves the machinability of the alloys considerably (*150*).

Bismuth has seldom been found in amounts larger than

TABLE III.

Tensile Strength (as cast), psi.	Frequency, per cent	Elongation, per cent	Frequency, per cent
25 000 to 26 000	3	1 to 2	15
26 000 to 27 000	7	2 to 3	55
27 000 to 28 000	19	3 to 4	30
28 000 to 29 000	32		
29 000 to 30 000	25		
30 000 to 31 000	14		

0.1 per cent in these alloys. It may be added from so-called free machining aluminum alloys or by stray pieces of bearing metals which also carry lead, tin, and sometimes antimony, into these alloys. All these elements improve the machinability of the alloys, and are otherwise relatively harmless in regard to mechanical properties when properly controlled. The total amount of all four elements should not exceed 0.7 per cent for sand and permanent mold castings (*150*).

It should be noted that the sand-cast alloy CC allows only 0.2 per cent zinc and only 0.3 per cent other impurities. The physical requirements for this alloy are the same as for the other three alloys which are obviously more "impure." In most cases where a double specification of this type is found, a reason such as "greater ductility" or "greater corrosion resistance" is given. Since this alloy contains more than 7 per cent copper and iron plus silicon of more than 2 per cent, a few per cent of the other elements will not make the alloy less corrosion resistant. Most of the elements which contribute to castability or machinability are missing. The resultant castings may be inferior and in consequence less resistant to corrosion for the same reasons given previously. Therefore, only greater ductility should be expected from this alloy. Strangely, however, it is not so listed in the specifications. It is quite possible to obtain equal ductility from the other alloys when the alloying ingredients are properly controlled.

In the first three alloys the minimum tensile strength and elongation required are relatively low. For permanent mold castings, only 23,000 psi. tensile strength and no elongation are required. An extensive study of this alloy was made by taking test bars daily from production furnaces for about 3 months. These bars were tested about 24 hr., 6 months and 1 yr. after pouring, and the change in properties recorded. It is very interesting to note that none of the test bars ever fell close to the minimum tensile strength of 23,000 psi. even when they had small defects and really should have been disregarded. Finally after 3 months of daily testing it was established that most of the test bars had a strength of 27,000 to 30,000 psi. and an elongation from 2 to 4 per cent. The data in Table III give the frequency of properties for several thousand bars.

TABLE IV.

	Elongation, per cent	Tensile Strength, psi.	Brinell Hardness
As cast	2.6	29 300	69
6 months	1.9	32 000	77
12 months	1.8	33 300	83

Chemical Analysis Variations, per cent

	Copper	Iron	Silicon	Zinc	Magnesium
Minimum	6.10	1.20	1.90	1.60	0.01
Maximum	7.10	1.45	2.80	2.40	0.06
Average	6.75	1.37	2.40	1.80	0.04

	Manganese	Nickel	Tin	Lead	Titanium
Minimum	0.13	0.20	0.20	0.30	0.03
Maximum	0.25	0.40	0.50	0.40	0.05
Average	0.17	0.35	0.35	0.35	0.04

These test bars gave general averages after casting, and after six and twelve months at room temperature aging as shown in Table IV.

These alloys have been used in great volume, in highly competitive fields, for widely diversified types of aluminum permanent mold and sand castings. Washing machine parts, such as agitators, gearhousings, wringer brackets; vacuum sweeper motor housings and nozzles; automobile cylinder heads, motor blocks, and crankcases; and by increasing silicon and magnesium, even pistons are successfully made from these alloys. There are many other uses to which these alloys are successfully applied. The ease with which they cast and machine and the relatively high strength have made them popular. It is surprising how little they are used in armaments, although they have very good properties comparable with many so-called higher grade alloys.

Group 2: 10 per cent Copper-Magnesium Alloy

The next group of alloys under consideration is a high copper alloy which has been used since before the first World War as a piston alloy. It is the 10 per cent copper alloy and its derivate, the 10 per cent copper 4 per cent silicon alloy. The main constituents are copper, iron, silicon, and magnesium. Copper at 10 per cent gives high hardness and strength at room and elevated temperatures. Iron and silicon add to these properties, as well as magnesium. The changes in properties caused by these elements are the same as discussed in group 1; thus, they need no repetition.

Magnesium, however, is in this alloy as an important desired element and makes possible the hardness which is obtained by proper casting and heat treatment. When properly heat treated, this alloy has hardness in the range of 100 to 140 Brinell, good machinability, and good bearing qualities.

It is interesting to note that *iron* in the alloys specified in B 26 – 41 T and B 108 – 41 T is allowable up to 1.5 per cent independent of the mode of casting—that is, sand casting or permanent mold casting. However, the silicon content in the sand-cast alloy is dependent on the iron content, and a total of both together of 2 per cent is allowable. That means, if the iron content is 1 per cent, only 1 per cent of silicon can be used. In the chill-cast alloy, 1 per cent of silicon can be used independent of the iron content. It is known, however, that silicon increases fluidity of aluminum alloys and also decreases shrinkage and by actual experience it has been found that stronger castings can be made when the silicon is increased to a minimum of 1.4 per cent. The proper proportioning of iron and silicon for the casting depends greatly on the intricacy of the design. The simpler the casting, the less important the proportioning. The higher the iron content, the more silicon is desirable. If, however, the silicon is more than 2 per cent, the iron should be kept below 1.3 per cent to avoid undue brittleness—illustrated in alloy 5.

Manganese imparts the same properties to this alloy as mentioned before and has marked advantage even up to 1 per cent, since it improves hardness and strength at elevated temperatures. It should be limited only by the fact that it decreases fluidity; but up to 0.7 or 0.8 the alloy casts without undue difficulty (*72*, *88*).

Nickel imparts about the same properties as manganese and can be used in greater quantities. In the permanent mold alloy it is limited to 0.03 per cent, and in the sand-cast alloy to even less. It can be used in much higher amounts such as 0.5 or even 1 per cent.

Zinc is limited in these alloys to 0.2 to 0.5 per cent. The sand-casting alloy has the lowest permissible zinc content. The properties obtained by the addition of zinc are the same in this alloy as in the No. 12 alloy. The greatest objection to zinc is the belief that zinc causes hot shortness and, therefore, weakness at elevated temperature. This idea probably dates back to the time when alloys with ten or more per cent of zinc were commonly used. It is very interesting to note from the specifications that in sand castings weakening of the alloy is expected to occur when more than 0.2 per cent zinc is present, while in chill castings 0.4 or 0.5 per cent is permissible, in spite of the fact that chill castings are much more troubled by hot shortness or weakness at elevated temperatures than sand castings. It seems logical, therefore, to assume that the specifications are not founded on facts. The author's tests on the effect of zinc on this alloy confirm that zinc is a harmless element as shown in Table V.

TABLE V.—10 PER CENT COPPER ALLOY.

Zinc, per cent	Tensile Strength, psi.		
	Room Temperature	302 F.	437 F.
0.10	32 100	30 300	28 600
0.25	32 300	31 500	28 500
0.40	33 500	31 700	28 400
0.79	34 700	31 800	28 200
1.22	33 700	31 600	28 700

In these tests the hot shortness decreased gradually with the addition of zinc. This seems to confirm that zinc up to 1.2 per cent has no deleterious influence on this alloy and can be used in greater amounts.

The *other elements* such as lead, tin, bismuth, and chromium, etc., including nickel in two of the alloys are limited to 0.3 to 0.5 per cent, respectively. If nickel is excluded for the above-given reasons from this list, then about 0.5 per cent of the "other elements" would greatly aid in the machinability of the alloy. The effect of the individual elements has been discussed in the No. 12 alloy and nothing new can be added in this case.

Alloy No. 5 is practically the same as alloy No. 4, only that 3 per cent silicon has been added, probably to increase the fluidity of the alloy. This alloy is, however, not used a great deal. It is interesting to note that in alloy No. 4 not more than 1 per cent silicon is allowable while in No. 5, 3.5 to 4.5 per cent silicon is wanted. It does not seem justified to conclude that the alloys with silicon from 1 to 3.5 per cent are useless.

It should be noted, however, that the composition of most alloys is very flexible and all the maximum limits of all elements given in the specifications cannot be used in any one alloy, since a second limitation—the physical property specification—controls the total amount of the alloying elements. To illustrate, we might choose the following examples:

Within the chemical limits of alloy 5 it is possible to produce alloys of greatly varying properties. An alloy with all elements at the low limits would be weak and soft and difficult to cast and machine, while an alloy with all elements at the high limits would be brittle. In Table VI the two extremes are illustrated as A and B. Alloy C has been added to the table for purposes of comparison.

Although this alloy does not conform to the chemical specification, the casting and machining properties are excellent and the physical properties are equal to or better than those alloys within the specification. The fact is that thousands of tons of pistons made of alloy C have been used for many years with great success in competition with the alloys F and 4.

Group 3: 4 per cent Copper-Silicon Alloys

This group of alloys actually contains three subgroups in which the silicon content varies in accordance with the mode of casting. Alloys G and GG of Specifications B 26 have a silicon content of 1.2 per cent maximum and are sand-casting alloys. Alloy 1-A of Specifications B 108 contains 2 to 3 per cent silicon for permanent mold casting to increase the castability; alloy 3 of the same specification contains 5 to 6 per cent silicon for more complicated castings. This same alloy is also used for die casting. This indicates plainly that silicon is a desirable element when fluidity or castability is wanted.

Iron in these alloys imparts the same properties as discussed before and need not be repeated.

Magnesium and all the other elements act identically in these alloys as in No. 12 type alloy or the 10 per cent copper alloy.

There is, however, one very interesting comment to make on the sand-cast alloys G and GG. A decided difference exists in the minor alloying elements. Alloy G is of greater purity. Since corrosion resistance is not influenced by relatively small amounts of minor alloying elements when more than 4 per cent copper is present, the only other objective in holding these elements so low would be to obtain greater ductility. The ductility, however, is greatly influenced by the presence of magnesium; hence, when ductility is required, it would be necessary only to reduce the magnesium content of alloy GG to 0.05 per cent. In either alloy the desired ductility can then be obtained provided the iron content be low enough (1 per cent max.) to facilitate heat treating. High iron reduces the ductility more than the presence of other elements such as manganese, nickel, zinc, and even lead and tin. It is found in the literature that small additions of silicon, magnesium, nickel, iron, and zinc improve the castability of the alloy (*152, 164, 173, 206*) while titanium lowers the elongation (*76*). Both alloys need titanium as a grain refiner which indicates that they are difficult to use for complicated castings. In other words, common alloying

TABLE VI.

Alloy	Copper, per cent	Iron per cent	Silicon, per cent	Magnesium, per cent	Manganese, per cent	Nickel, per cent	Zinc, per cent	Others, per cent	Total Hardener, per cent
A	9.25	0.2	0.2	0.15	0.03	0.00	0.01	0.05	9.89
B	10.75	1.5	1.0	0.35	0.3	0.3	0.4	0.3	14.90
C	9.5	1.1	1.6	0.25	0.4	0.35	0.6	0.5	14.3

TABLE VII.—SAND-CAST 4 PER CENT COPPER ALLOY.

Test Number	Chemical Composition per cent											
	Copper	Iron	Magnesium	Manganese	Nickel	Silicon	Zinc	Lead	Tin	Bismuth	Chromium	Titanium
X 250	4.10	0.32	0.01	0.64	0.02	0.70	0.07	0.14	0.14	0.14	0.01	0.02
X 251	3.96	0.88	0.01	0.46	0.05	1.07	0.15	0.10	0.10	0.04	0.03	..
X 265	4.32	1.12	0.04	0.14	0.04	0.70	0.70	0.24	0.12	0.08	0.03	0.03
X 268	4.57	0.92	0.07	0.26	0.14	0.93	0.56	0.10	0.16	0.04	0.03	0.05
X 197	4.21	0.68	0.06	0.43	0.05	0.86	0.39	0.14	0.10	0.07	0.01	..

PHYSICAL PROPERTIES

HEAT TREATMENT: 12 HR. 960 F., QUENCHED, AGED 1 HR. AT 212 F.

Test Number	Hardness Rockwell, "E" scale	Proportional Limit, psi.	Yield Strength, psi.	Tensile Strength, psi.	Elongation, per cent
X 250	71	12 900	17 400	30 500	5.2
X 251	70	10 500	16 300	30 800	5.4
X 265	66	12 300	18 000	30 500	5.1
X 268	74	16 300	24 000	34 000	4.0
X 197	67	15 000	21 600	33 400	4.5

elements which will improve castability cannot be used in alloy G, but titanium can be added to counteract the deficiency in castability. Small amounts of minor elements are very desirable in this alloy: (1) for the reasons given above, and (2) to improve the poor machinability of the alloy. Again it should be recalled that the physical properties are the yardstick for the quality of the alloy, and the chemical specification only a guide for the user.

Table VII illustrates the properties found on commercial (secondary) heats of alloy of the type covered by Specifications B 26, alloy G. They show that quite satisfactory properties are obtained through a wide variation in composition. It should be noted that the elongation is lower than in the high pure alloys, but the yield strength is appreciably higher.

The permanent-mold alloy No. 1A of Specifications B 108 suffers from the same deficiency of minor alloying elements, as the alloys G and GG above. It has been found in practice that the *iron* content in this alloy can be considerably higher than in the sand-cast alloys of this type and up to 1.20 does not interfere with the ductility or heat treatment (*179*).

Magnesium interferes with ductility and should not be higher than 0.05 per cent where more than 4 per cent elongation is desired.

Manganese can be used up to 0.7 per cent; *nickel* up to 0.5 per cent; *zinc* up to 1.2 per cent. Lead, tin, cadmium, bismuth, chromium, and titanium have the same influence as mentioned before and should be used for good machinability.

Table VIII gives an interesting résumé of the statements made for alloy 1A (Specifications B 108). For 2 yr. tests have been conducted on every heat of metal made. More than 14,000 bars were tested and the properties and analyses statistically recorded. The table gives the frequency of tensile strength and elongation as they were found in 1939 and 1940, and also the average for the 2-yr. period. The majority of alloys tested between 36,000 and 42,000 psi. tensile strength and 5 and 8 per cent elongation. The chemical analysis during these two years varied between the limits given in the table. It also should be mentioned that all these heats were accepted by our armed forces and used for war production.

The alloy 3 of Specifications B 108 is used for complicated castings of which relatively low properties are required. It should not be compared with the alloys above as far as ductility is concerned. However, the influence of the minor alloying elements is the same on this alloy, and they should be used to the same advantage. The properties of this alloy could be improved considerably by heat treatment.

TABLE VIII.—FREQUENCY OF PROPERTIES OF 4 PER CENT COPPER, 2 PER CENT SILICON ALLOYS.[a]

Chill Cast: Solution heat treated; aged 2 hr. at 212 F.

Tensile Strength, psi.	Frequency, per cent		
	1940 Period, 8825 Bars	1939 Period, 5462 Bars	Average
33 000 to 34 000	0.0	1.0	0.5
34 000 to 35 000	0.7	2.4	1.5
35 000 to 36 000	6.9	7.4	7.1
36 000 to 37 000	13.4	11.6	12.5
37 000 to 38 000	16.4	13.6	15.0
38 000 to 39 000	17.7	16.9	17.3
39 000 to 40 000	16.2	17.0	16.6
40 000 to 41 000	14.2	13.7	12.5
41 000 to 42 000	9.9	10.9	10.4
42 000 to 43 000	4.5	3.7	4.1
43 000 to 44 000	0.5	1.5	1.0
44 000 to 45 000	0.3	0.3	0.3

Elongation, per cent	Frequency, per cent		
	1940 Period, 8825 Bars	1939 Period, 5462 Bars	Average
4 to 4.5	0.0	0.3	0.1
4.5 to 5	1.0	3.4	2.2
5 to 6	21.1	25.7	23.4
6 to 7	47.7	46.0	46.6
7 to 8	24.5	20.6	22.5
8 to 9	5.4	3.7	4.6
9 to 10	0.8	0.3	0.5

Chemical Analysis of Alloys, per cent

	Copper	Iron	Magnesium	Manganese	Nickel	Silicon
Low	3.9	0.8	0.01	0.2	0.1	1.9
High	4.7	1.1	0.07	0.6	0.5	2.8

	Zinc	Tin	Lead	Chromium	Bismuth	Titanium
Low	0.1	0.1	0.05	0.01	0.0	0.02
High	0.6	0.2	0.20	0.15	0.1	0.20

[a] Specification: 33,000 psi. tensile strength; 4.5 per cent elongation, minimum.

GROUP 4

The same alloy No. 3 is found as No. VII of Specifications B 85 as a die-casting alloy. However, the composition as far as minor elements are concerned is much different. The iron content is more than twice as high as in the permanent mold alloy and undoubtedly too high to give maximum properties. This limit of 2.3 per cent was set to accommodate the die caster of olden times, who had difficulties in preventing iron pickup from the die-casting machines. However, in modern machines of the cold-chamber type, the aluminum does not pick up much iron, and it should be possible to reduce the iron content and thus improve the ductility of the alloy.[5] Magnesium is

[5] This has been recognized lately and new specifications have been approved in which the iron content has been reduced in castings made on the gooseneck machines to 2.0%, and on cold chamber machines to 1.3%. These alloys are now known as VIIA and VIIB, respectively.

high enough to cause age hardening at room temperature; it should by no means exceed 0.1 per cent.

Manganese is considered quite beneficial in die-casting alloys since it is said to prevent the sticking of the casting to the die. Furthermore, it reduces hot shortness and modifies the effect of high iron. Therefore, it is a very desirable element for the die caster and its content in this alloy should be increased to 0.6 per cent (*72*, *88*).

It is again interesting to note that zinc is tolerated up to 1 per cent in die castings although it is said to cause hot shortness in sand and permanent-mold castings when used in excess of 0.2 or 0.4 per cent.

Tin is also permissible in die-casting alloys while it is said to cause hot shortness in other modes of casting.[6]

Nickel is permissible up to 0.5 per cent. If it does no harm in the die-casting alloy it should also be harmless or equally beneficial in the sand and permanent mold alloys of this type.

In alloy IX of Specifications B 85 the silicon content is decreased to about 2 per cent and the nickel increased to about 4 per cent. This is, of course, a different alloy and cannot be directly compared with the alloy VII. However, it has nearly the same physical properties. The iron content is somewhat lower, but manganese is still 0.3 per cent maximum as in most other alloys, although higher amounts are beneficial for the above reasons. The two alloys are practically obsolete and specifications have not been modernized. But they are still carried in the specifications.

The most interesting part of alloy IX of Specifications B 85 is the high nickel content. While thus far nickel has been treated as an undesirable impurity, in this alloy it is considered a desirable alloying element. This alloy has nearly the same physical properties as alloy VII. It is further interesting to note that the only difference between the two alloys is the replacement of 3 per cent of silicon in alloy VII by 3 per cent nickel in alloy IX. Both have nearly the same properties. This seems to imply that 1 per cent of silicon is equivalent to 1 per cent of nickel in copper-aluminum alloys. In alloy VIII the copper is much lower than in the previous alloys. The silicon content is also down to near 1 per cent, and the nickel content is reduced to about 2 per cent. This alloy exhibits greater ductility than most of the other die-casting alloys. The iron content is higher than in alloy IX, and the magnesium content also is higher, reducing the ductility of the alloy to some extent. Manganese as usual is 0.3 per cent. The zinc content, however, has been reduced to 0.5 per cent. It is hardly reasonable to suppose that in this alloy which has basically the same composition as the two previously mentioned alloys, more than 0.5 per cent zinc should be harmful. Since zinc is a very mild hardener and is also desirable as far as castability is concerned, the zinc limit could be increased to 1 per cent.

The next two alloys, alloys H and 11, the sand-cast specification and the permanent-mold specification, constitute an old alloy generally known as Y-alloy. In both alloys the chemical specifications are identical. The physical specifications differ slightly. The sand-casting alloy requires a minimum of 32,000 psi. while for the permanent-mold casting a minimum of 33,000 psi. tensile strength is required under heat treatment No. 1. The three main alloying constituents of the alloy are copper, magnesium, and nickel. Copper is within the limits of 3.5 to 4.5 per cent, as in many of the previous alloys. Nickel is limited to 1.7 to 2.3 per cent, and the interesting element in this alloy, magnesium, from 1.2 to 1.8 per cent. This is the first alloy we have considered in which magnesium is desired in amounts above 1 per cent, and we have thus gone through three stages: (1) magnesium as an undesirable impurity; (2) as a desirable element in small amounts; (3) as a desirable element in higher amounts. Magnesium has a high affinity for silicon and forms the hardening compound, magnesium silicide. It is, therefore, necessary to limit the silicon to low amounts, and in this case, 0.7 per cent is the maximum allowable (*44*). If higher amounts are present, the hardness is so great that the alloy becomes nearly brittle.

The nickel content imparts to this alloy its resistance to softening at elevated temperature (*110*, *122*). This alloy has been used for many years for cylinder heads and pistons where relatively high temperatures prevail. The manganese content is again limited to 0.3 per cent as in most of the other alloys thus far, and there seems to be no basis for this limitation. It has been found by experience that nickel and manganese can be partly substituted for each other, and if higher manganese is found in the alloy, not as much nickel is necessary to get the same results. At this time the supply of manganese seems to be less critical than nickel. Hence, it would be of advantage to use manganese to partially replace nickel in such alloys as Y (H and 11). Even with nickel at the top limit of the specification, the higher manganese content may be desirable. Zinc has been limited in these alloys to an extraordinary extent. The earlier specifications for these alloys limited zinc to 0.01 per cent. Later this specification was "relaxed" and 0.03 was allowed. Within the past year or so the zinc limit was increased to 0.1 per cent. This low limit was supposed to prevent hot shortness in the alloy. This supposition, of course, is wrong, since it has been found definitely that zinc does not cause hot shortness. Tests made by the author on these alloys indicate that zinc content as high as 3 per cent does not decrease the strength at elevated temperature. In fact, it increases the strength at room temperature and the alloy maintains its strength at elevated temperatures as shown in Table IX.

Zinc was added to the alloy in steps of 0.2 per cent up to 1.3 per cent, and an increase in tensile strength was noted. Also an increase in hardness can be observed. With this increase in tensile strength and hardness, the hot shortness as measured in a permanent mold was reduced from 20 per cent on the zinc-free alloy to 8.5 per

TABLE IX.

Copper, per cent	Iron, per cent	Magnesium, per cent	Silicon, per cent	Nickel, per cent
4.10	0.39	1.63	0.23	1.83

Zinc, per cent	Tensile Strength, psi.			Brinell Hardness		
	Room Temperature	302 F.	437 F.	Room Temperature	302 F.	437 F.
0.03.....	32 200	31 100	30 000	91	89	90
0.22.....	34 800	34 300	31 200	92	93	93
0.42.....	35 500	33 500	31 800	93	95	95
0.66.....	36 100	34 200	32 900	97	95	98
0.76.....	36 500	35 000	33 000	99	100	99
1.34.....	37 800	36 100	34 000	101	100	99

[6] See p. 48.

cent on an alloy containing 1.3 per cent zinc. It will be seen in the table that the alloy containing 1.3 per cent zinc has a tensile strength of 37,800 psi. at room temperature, and at 302 F. the alloy has a tensile strength of 36,000 psi. At 437 F. the strength is 34,000 psi. The alloy without zinc never reaches such a high tensile strength at room temperature. At 437 F., the alloy containing 1.3 zinc is 10 per cent stronger than the alloy containing no zinc.

A heat treatment, corresponding to heat treatment No. 2, and also a treatment A to produce greater ductility was given to these alloys. These tests gave properties as shown in Table X.

TABLE X.

Zinc, per cent	Tensile Strength, psi.	Elongation, per cent	Brinell Hardness	Heat Treatment
0	50 000	0.5	114	2
1.3	59 000	0.5	125	2
0	47 500	1.5	110	A
0.7	51 000	1.5	121	A
1.3	52 000	1.5	127	A

These tests demonstrate conclusively that zinc is a desirable addition to this alloy—it increases the tensile strength and hardness without reducing the elongation. The increase in tensile strength in this alloy by addition of zinc is remarkably high. It can be increased as much as 20 per cent, by adding 1.5 per cent zinc, without reducing the ductility of the alloy noticeably.

The other elements in the alloy of this specification are kept to 0.3 per cent. These other elements include lead, tin, and titanium which are frequently added to improve the machinability of the alloy. A higher percentage, such as 0.5 or 0.6, of these elements will improve the machinability without interfering with the physical properties of the alloy. The iron content is limited to 1 per cent,[7] which probably is correct for the sand-casting alloy although the permanent-mold alloy could stand somewhat higher iron without losing any of the desirable qualities. Especially when a higher amount of manganese is present, the iron could be as high, probably, as 1.4 per cent.

These two alloys complete our study of a group of alloys in which copper is really the main alloying element. The copper content ranges from 10 per cent down to 7, 4, and finally 2 per cent. The intentional additions to these alloys are silicon, nickel, and magnesium. All other alloying elements present in these alloys are considered as impurities, but even some of the main additions are considered impurities in many of the alloys. For example, the magnesium is generally considered as an undesirable impurity. Also the nickel is considered in most alloys as an undesirable impurity. And even silicon, in some of the alloys, is not desired. We should summarize that in copper alloys, silicon is always desirable since it increases the fluidity of the alloy and also reduces the hot shortness. The only alloy where silicon is not desired is the Y-alloy, in which the magnesium forms magnesium silicide, a powerful hardening compound. Magnesium is not desired in most of the alloys with the exception of the 10 per cent copper alloy and Y-alloy. In the 10 per cent copper alloy only small amounts such as 0.3 per cent are necessary to cause sufficient hardening. In Y-alloy about 1.5 per cent is specified to give the desired properties. Nickel is very much desired when high strength at elevated temperature is required. It should be logical to suppose that this property is also desirable in other alloys, and a rigid limitation of nickel at percentages such as 0.1 or 0.3 per cent should be avoided.

Manganese seems to be limited to 0.3 per cent in most of the alloys for no apparent reason, and since it imparts very desirable properties to the aluminum alloys, it would be wise to increase the amount of manganese considerably, to get properties such as reduced hot shortness, reduced brittleness, higher strength at elevated temperatures, better machinability, and better dissemination of the iron compound in the alloy. Zinc, of course, is the element which has been most badly "maligned" and enough has been said in the previous paragraphs about zinc so that it does not need to be repeated here. The iron content depends largely on the mode of casting and, as stated above, it does not have to be as high in the die casting as the specifications allow, while in some of the permanent-mold casting alloys the content could be increased slightly without ill effect. The other alloying elements such as lead, tin, bismuth, and antimony all improve the machinability of the alloys and seldom reach very high amounts, probably very seldom 1 per cent total. They are neither hardening nor embrittling, can be controlled properly, and therefore are relatively harmless.

Nonmetallic Impurities

One subject has not been discussed in all these alloys, and that is the question of nonmetallic impurities, such as oxides, nitrides, and the like. The statement is often made that remelt alloys contain more oxides than so-called high-purity alloys. It is unfortunate indeed that it is not possible to analyze for aluminum oxide and obtain reliable results which can be consistently repeated. There is not one method which has been approved as dependable by any group of scientists. Therefore, it is easy for anyone to make the above statement. However, there is sound reasoning which can disprove it. Virgin aluminum, as it comes from the reduction cell, where it is born out of oxides, is loaded with oxides and fluxes to such an extent, that to make it usable, it has to be remelted and cleaned of these impurities by fluxing, skimming, and holding in the furnace. Fluxing, skimming, and holding the metal are identical procedures in the production of virgin and remelt metal, and there is no basis for the assumption that these methods work any differently on virgin aluminum than on remelt aluminum.

When the above-mentioned refining methods are employed, it is possible to "purify" aluminum, even virgin, from nonmetallics to such an extent that it becomes coarse crystalline so that castings made from it are unsatisfactory, due to shrinkage. When, by the use of modifiers, oxides or other nonmetallics are again introduced into aluminum alloys, the casting properties are improved and the metal exhibits superior properties to the superpurified metal. There is a definite similarity in other metals such as, for example, fine-grained steel.

It is, of course, possible to remelt aluminum and not remove the excess of nonmetallics properly. This often happens when foundries reclaim their own scrap without adequate facilities and technique to condition the metal properly. This is most likely the reason why nonmetallic

[7] Tests are conducted today to substitute 1 per cent nickel in this alloy by 1 per cent added iron, giving a total of 2 per cent iron.

impurities and remelt metal have become so closely associated in the minds of many. They do not realize that primary aluminum must be remelted to remove the nonmetallics. This same reasoning must be brought forth when the gas content of these alloys is considered.

"Remelted" aluminum has been in competition with primary metal for many years, and when the composition of the remelted aluminum is comparable with that of primary, no difference in properties is found. That should be conclusive, both on the question of oxides and on any other prejudicial opinions regarding remelt aluminum.

Summary

Our discussion indicates that, with certain exceptions noted below, the effect of the minor alloying elements on the mechanical properties of aluminum-copper, aluminum-copper-silicon, and aluminum-copper-nickel alloys is either beneficial or innocuous. The only element which requires rigid control is magnesium. In all these alloys (with the exception of the 10 per cent copper and the Y-alloy) 0.10 per cent magnesium is the maximum which can be tolerated without causing loss in ductility. In cases where ductility is of prime importance, limitation of magnesium to 0.05 per cent is indicated.

Iron is the next element which must be watched carefully. Since much of the contamination arises through the foundry process, every precaution should be taken to prevent unnecessary iron pickup. This is the more serious as the silicon content increases.

All the other elements such as manganese, titanium, nickel, chromium, and cobalt in one group; and tin, lead, antimony, bismuth, and cadmium in another group, are usually present in small enough amounts so that there is no harm; in fact, we pointed out, in many cases great advantages occur when they are present. Furthermore, with good laboratory control and proper technique, these elements can be balanced so that the maximum benefit is gained by their presence.

One fact should be stated; that in many cases the presence of the elements mentioned in the above discussion sometimes changes the casting characteristics—and some adjustments in the foundry practice may have to be made to suit the alloy. In many cases, the alloys have a somewhat lower melting point and greater fluidity; therefore, the pouring temperatures can be lowered.

There seems to be a question about what are the important physical properties on which the designer and engineer can rely. In most specifications only a minimum tensile strength and elongation are given which would imply that these two are the only properties which the engineer requires. In many alloys the elongation seems to be of prime importance. It is, however, certain that a casting stressed to an extent of considerably less than one-half of the required 6 per cent minimum elongation could only be used where dimensional stability does not matter. A casting must be strong enough to resist deformation. The measure for resistance to the earliest stages of permanent deformation is the proportional limit and the yield strength and not the elongation and tensile strength found in a fractured test bar or casting. It appears reasonable to class an alloy having 16,000 psi. proportional limit, 24,000 psi. yield strength, 34,000 psi. tensile strength, and only 4 per cent elongation superior in regards to dimensional stability under stress to an alloy having only 10,000 psi. proportional limit, 16,000 psi. yield strength, 34,000 psi. tensile strength, and 8 per cent elongation. Differences of this order are commonly found between remelt aluminum alloys and primary alloys. Remelt alloys usually exhibit the greater proportional limit and yield strength and somewhat lower elongation. It therefore seems advisable to supply the designing engineers with data on proportional limit and yield strength in addition to the present information on tensile strength and elongation. If these data were made available for aluminum alloys, the question of composition would be simplified.

This concludes the first part of the discussion on the effect of minor alloying elements on aluminum-copper and aluminum-copper-silicon alloys. The second part which covers the aluminum-silicon base alloys will be given at a later date.

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Electrical Testing Laboratories, Inc.

AFTER 40 YEARS of a testing career, the utility-owned Electrical Testing Laboratories was dissolved last winter. This occurred at the height of its career and in the face of increasing utilization of its services by the electrical industry and others.

Upon dissolution of the old company the employees organized a new company, chartered in New York State as Electrical Testing Laboratories, Inc. This new company purchased the plant and equipment of the old company, located at East End Avenue and 79th Street, New York City, and elsewhere. It took over the personnel of the old company intact and instituted a new technical service to replace that abandoned by the dissolved company.

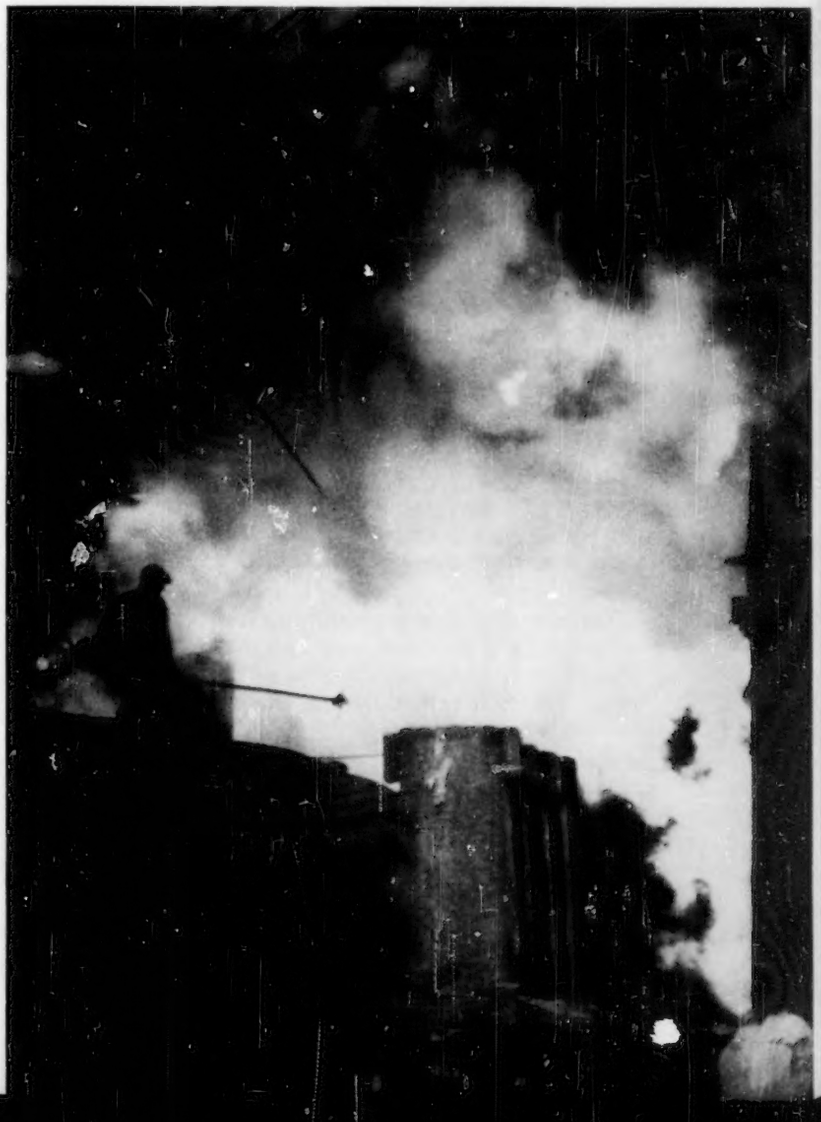
On May 8, 1942, an inaugural meeting at the plant was addressed by the heads of six nation-wide technical organizations, while messages were received from five other such leaders, including Dr. G. E. F. Lundell, then President of the A.S.T.M. This affair signalized the renewal of the testing enterprise under wholly independent auspices and made evident a continuance of the participation of ETL people in the work of the A.S.T.M. and other engineering and technical societies. A booklet constituting the proceedings of that meeting has been printed and may be obtained upon request from Electrical Testing Laboratories, Inc.

OEM Handbook

ISSUED IN MAY is a 72-page pamphlet describing the functions and authorities of the Federal war agencies whose activities are coordinated within the Office for Emergency Management. It also gives information on related agencies. Anyone having contacts with the various offices and divisions including the War Production Board and its various divisions and bureaus may find the Handbook worth while. Copies can be obtained free of charge on request from Press Release Services, War Production Board, Room 1501, Social Security Building, Washington, D. C.

"Smoke, Steel and Brawn"

Honorable Mention, Professional, in the Fourth A.S.T.M. Photographic Exhibit, by Thor Nielsen, Carnegie-Illinois Steel Corp.



ASTM Bulletin

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Aspects of A.S.T.M. Publications

THE EXTENSIVE list of A.S.T.M. publications scheduled to come off press before the end of the year and on which information is given in an article in this BULLETIN justifies some comment.

From the standpoint of Society income it is not only interesting, but significant, to note that about 15 years ago—the period 1928 to 1930—the revenue from sales of all publications approached 25 per cent of the total A.S.T.M. income, the dues being about 60 to 65 per cent of the total, the balance, miscellaneous items. For the last three years—1940, 1941, and estimated 1942—income from sales represents roughly 40 per cent of the total, with dues about 47 per cent (1940 publication sales actually aggregated 43.3 per cent), so that the income from publications represents a most appreciable portion of the Society's income and its maintenance means that A.S.T.M. can do many things in standardization and research that might not otherwise be possible.

Practically all of the Society's publications are made available to members at appreciable reductions in price, which depending upon the number of copies and the particular publication may be a considerable percentage of the list price.

The relatively low prices charged for a number of the books—for example, the special compilations of standards—are made possible by using standing type from which the Book of Standards or other publications have been printed. Every effort is made to have the books pleasing in appearance, clearly printed, and substantially bound. The one criterion which governs decisions is always "what will make the books most useful." While the financial phase of publications is interesting and obviously a very practical one, there are other phases which are perhaps just as significant.

For the Society's standardization work, and research in promoting knowledge of the materials, to be most widely effective the results must be used. They can only be used if those responsible for the production and use of materials know that there is an A.S.T.M. and that it has issued numerous specifications and tests in a particular field or has published data. And so the publications are an essential factor. The steadily growing use of standards has been stimulated in a great measure by the widespread distribution of the Book of A.S.T.M. Standards and the purchase and use of thousands of copies of the special compilations of standards in specific fields—petroleum, textiles, refractories, etc. Each has contributed to an extent not possible to evaluate, in more effective utilization of materials.

It is not at all uncommon to be discussing a publication with some member or non-member—for example, the Manual on Refractory Materials—and have him say "Why of course I know that publication—it's our bible"—meaning that in evaluating the materials he buys and produces, or both, he depends on the A.S.T.M. specifications for the quality basis, and on the tests to inform him what certain properties may be.

The war emergency has stimulated the demand for certain A.S.T.M. publications to a degree much greater than the normal industrial upswing would insure. This is particularly true, for example, in the case of the Symposium on Radiography and X-ray Diffraction; also, the special compilation of Selected Standards for Students in Engineering which has been used very widely in the national defense training courses. A daily glance at the labels on the packages coming from the A.S.T.M. shipping room shows that the Books of Standards are going to all parts of the United States and its possessions, for use in construction work, production of defense materials, and related categories.

Much more about these publications might be said, but we must get busy and produce some books.

President Ball Writes:

I UNDERSTAND IT is my privilege as your President to fill a portion of this space from time to time with such thoughts or messages as I may wish to communicate to the members of the Society. Whether the demands upon one's time in these work-filled days will permit me to avail myself of this privilege in each succeeding issue of the BULLETIN remains to be seen. So far as this issue is concerned I feel I should take some time out of a four-day vacation period which I am enjoying on Cape Cod (and which I suspect is the only vacation which will come my way this summer) to formulate one important thought that is on my mind.

The particular spot where I am writing this is on the south side of the Cape at a place where the pine woods come right down to the shore line. Out of the southwest blows the soft, balmy, moisture-laden air from off Nantucket Sound to blend with that delightful and indescribable fragrance of the red pines. Together with the warm sun, the constant swish of the surf on the sandy shore, the ceaseless, quiet stirring of the breeze in the beach grass and amongst the pines, there results a combination not exactly conducive to effort of any kind.

It might make one forget momentarily that we are engaged in a war which is shaking the very foundation of civilization and society were it not for the appearance of a blimp that slowly and quietly moves up the coast or for the more frequent and noisy passage of observation planes from a nearby airport as each goes out over the sound on its respective missions. And it is this which brings me to the main point of this message.

The struggle in which we are engaged is one which,

according to its outcome, spells our freedom or slavery. To freedom-loving Americans there can be one and *only one* answer. The main issue of the moment, therefore, is that each one shall assist in every possible way any effort which will help in any degree, large or small, to bring this war to an early and successful conclusion. Nothing else seems to matter.

To this end the officers and the Executive Committee of the Society have been giving and will continue to give their best thought to plans which will make the influence of the A.S.T.M. most effective for this purpose. I recognize the valuable work and service which hundreds of our members are rendering toward this same goal, and I choose this opportunity to stress the need for the continuance of equal or greater efforts if possible during the coming year.

Herbert J. Ball

PRESIDENT

Haste and Waste

THESE ARE hectic days when technical activities need very careful guidance. Also they need the type of individual who has had a very broad training and experience, to avoid overlapping efforts and particularly to obviate doing work which may already have been started, partially accomplished, or even completed.

Certainly haste is very important in some of the problems needing solution, but there are instances where too much hurry and too little consideration of all factors involved have resulted in waste of valuable time and effort. We have in mind a recent case where a special "war" committee, very anxious to do good work, actually undertook the establishment of certain specifications not cognizant of the fact that a leading organization through one of its groups had already done outstanding work in this respect, which specifications had been published and rather widely used for two or more years. Fortunately one of the members at a second meeting set this situation straight. Undoubtedly, there are many other cases where there have been overlapping and conflicting efforts.

Those in charge of activities in technical groups have a great responsibility to see that the time of their committee members and those cooperating is not expended in work which has been started elsewhere, which can be better accomplished in some other method or possibly can afford to wait until ideas are better crystallized.

More About Manganese

THE EXTREMELY tight situation respecting molybdenum, which now finds itself on the pinnacle previously occupied by such steel alloying companions as nickel, vanadium, and chromium, and conflicting statements concerning the manganese position, prompts some review of this situation. Some have indicated that conservation of manganese was not too essential since there seems to be an abundance of the element while others have held that it must be conserved. We feel that the latter is the safe course considering all extenuating circumstances. Dr. C. H. Herty who is chairman of a special Iron and Steel Institute committee on manganese, at a recent meeting outlined the situation which is approximately a twenty month stock of manganese ore that until recently had been gradually rising. However, of our total yearly manganese ore consumption only about ten per cent is domestic; the balance is subject to hazards of shipping and the shipping available in the location of the ore deposits.

Recently there has been considerable mention of an increased domestic supply, an uncomfortable portion of which may not materialize at all and some of the projected balance may be many months in developing.

New alternate alloy steels which are being agreed on all have higher manganese and on top of this are increased tonnages of alloy steels.

Along with the hazards of shipping and the probable increase of manganese consumption per ton of steel there is the uncertain but very probable drain on manganese in view of the molybdenum situation. It seems reasonable to believe that conservation of manganese should continue to be practiced and should be intensified. It is absolutely essential that sufficient manganese be maintained for the normal function of promoting good rolling properties. Dr. Herty's committee is giving further consideration to this matter as it affects specifications, and we are not inclined to comment further at this stage except to repeat the closing statement in our January BULLETIN commenting upon this manganese question, namely, that "since we do not have an overabundance of manganese, we must manage it efficiently."

Wanted — Scrap

FORMATION OF the American Industries Salvage Committee, representing groups of leading industrial concerns who are working with the Conservation Division of the War Production Board to help speed the collection of vital scrap materials, has been announced by Robert W. Wolcott, chairman of the group and President of Lukens Steel Co.

Other members of the administrative committee directing the nationwide campaign are: Charles R. Hook, president, American Rolling Mill Co.; R. S. Wilson, Rubber Manufacturers Association; and O. E. Mount, Steel Founders' Society of America.

The work of the committee, backing up a broad advertising program, will be two-fold: one, to reach every manufacturing and business firm in the nation to impress upon them the absolute necessity of getting their scrap on the way to the production line; and, two, to get business men cooperating with the local salvage committees of the WPB.

The activities will be coordinated with the present intensified scrap collection drive. In this connection, the committee through a number of major industries is underwriting the cost of an extensive national advertising campaign approved by the WPB.

The advertising focuses the spotlight of public attention upon the need for iron and steel scrap, non-ferrous metals, rags, burlap, rubber, tin cans (in some localities), and waste cooking fats.

"Our committee, through the leaders which it is appointing in each trade," Mr. Wolcott said, "intends to obtain assistance for the WPB's drive in as many companies as we can reach. We hope to release for war use unusual sources of scrap which may have been largely untapped, such as obsolescent machinery, unused dies and jigs, and other types of idle plant equipment. By carrying out this campaign on an industry-by-industry and company-by-company basis, we feel that we can gear the effort to the individual trade's scrap possibilities."

Heavy Publication Schedule Includes 1942 Book of A.S.T.M. Standards

Also Special Compilations of Standards and Numerous Technical Volumes

DURING THE NEXT few months, those responsible for the various A.S.T.M. publications—which includes not only the Headquarters Staff, but many officers of the Society and its technical committees who cooperate very closely—are confronted with the heaviest publication schedule that A.S.T.M. has had. In recent years, the number of reprints, symposiums, and compilations published has been increasing and with the advent of the Book of Standards year there comes a train of complete new editions of a number of books.

The so-called "regular publications" which include Book of Standards, *Proceedings*, Year Book, Index to Standards and Tentative Standards will, of course, be supplied to the members in accordance with previous practice, and a list of other current publications will be sent in the form of an order blank to each member late in September. This will include brief descriptions and expected date of appearance, with information on special prices to members. In advance of this detailed list, there are given below notes on some of the publications so that members will have some advice on the approximate publication date, and be given other information on A.S.T.M. books, many of which are unusually important in connection with the war emergency. The numerous special compilations of standards in point of view of their very widespread distribution and use have become particularly significant. New editions of practically all of these are scheduled this year as indicated.

In connection with the approximate publication dates given, they, of course, cannot be guaranteed because there are many factors which enter into the time of appearance of any given publication. Sometimes a committee may have to take action on a particular standard and there is some delay; possibly the author of a technical paper may have been forced to delay returning proof, etc. Also, some flexibility in publication dates of compilations and technical publications is desirable, in order that one which may develop to be more urgently needed can be given preferential treatment.

Regular Publications

1942 Book of A.S.T.M. Standards

In his presentation of the annual report of the Executive Committee, C. L. Warwick, Secretary-Treasurer, pointed out that the most important work before the Society in the immediate future is to push the publication of the 1942 Book of A.S.T.M. Standards. This Book will again be issued in three parts as follows:

Part I, Metals.
Part II, Nonmetallic Materials—Constructional.
Part III, Nonmetallic Materials—General.

Each of these books will be among the most extensive publications issued by the Society, estimates (usually very conservative) indicating a total number of pages of 4900, about evenly distributed—but with Part I being the largest book; Part II, the least bulky. Tentative publication dates for the respective parts have been set as December 15, November 20, and December 1, with every effort being made to anticipate these dates.

Those who have had frequent reference to the Book of A.S.T.M. Standards and have had to use nine books this year, which include the three original 1939 volumes and the three 1940 Supplements and those issued in 1941, will welcome the appearance of the new book. Distribution of the Book of Standards is extremely widespread and the war emergency has stimulated a demand for the publication to such an extent that all copies in stock are being carefully husbanded and many of those who procured complete sets of the book have been approached to determine if they would not sell back to A.S.T.M. Parts II and III so that companies and Government agencies who have urgent need of the books could obtain them. The number of copies of the books printed was considered more than ample.

Among the important decisions which will need to be reached is the disposition f the emergency "pink slips" which are growing in number as indicated in another part of this BULLETIN. Whatever method is used, it will be one which will bring to the members the most logical arrangement of the material.

1942 Proceedings

The *Proceedings* of the annual meeting will again be issued as one volume including both committee reports and technical papers, with discussion. Because of the urgency of expediting the Book of Standards and related publications, printing of the *Proceedings* is being scheduled for late in the year, with distribution sometime in January, 1943. Meanwhile, many of the papers are being reprinted in advance; some committee reports are also being issued as part of some one of the special compilations. Estimated pages in the *Proceedings*, about 1400.

1942 Index to Standards and Tentative Standards

This Index, which continues to increase in value as the number of specifications becomes larger, will again give the latest complete references to publications where the various specifications and test methods appear. The Index is furnished to members, and is also widely distributed on request (more than 17,000 copies of the 1941 Index were distributed). Publication of the new edition is scheduled for late in December. This will probably aggregate 230 pages.

Year Book

Includes a list of the complete membership of the Society (name, classification, address, company, etc.), the personnel of all A.S.T.M. committees, and other pertinent information. Furnished only to members on request, for use in connection with activities of the Society. Publication date of this 340-page book—about September 25.

Special Publications

1942 Marburg Lecture

There was great interest in this year's Marburg Lecture on "Gasoline—Past, Present and Future" by Dr. Graham Edgar, and prior to its publication in the 1942 *Proceedings*, special reprints of the lecture are being issued. This will aggregate about 20 pages and will be available about September 1. It is published in special format. Copies can be obtained by members at 35 cents each.

Symposium on Radiography

The thirteen technical papers and extensive discussion presented in three sessions of the 1942 annual meeting will form the basis of the published symposium which, however, will include some of the material on X-ray diffraction which constituted the very extensive 1936 symposium, the first of its kind to be published

in the English language. There is urgent need for this latest symposium, the 1936 edition having been exhausted, and the officers of Committee E-7 on Radiographic Testing are expediting review and editing of the papers and discussion. Estimated to run about 300 pages, the symposium is scheduled for publication in October.

Significance of Tests of Concrete and Concrete Aggregates

This 1942 edition will be an extensively revised and considerably amplified version of the original report which was published in March, 1935, and included 17 papers by outstanding authorities in the field. The 1942 book will have 23 technical discussions each of which will have been approved by Committee C-9 on Concrete and Concrete Aggregates, which is responsible for the publication, through a special committee under the chairmanship of R. W. Crum. The papers will again be segregated, covering tests for concrete, tests for aggregates and general discussion and introduction. Estimated to comprise some 160 pages, the publication date is somewhat uncertain, because committee action still needs to be taken on some of the items, but is tentatively set as October 1.

Symposium on Spectrographic Analysis

Because of steadily intensified interest in this subject, Committee E-2 on Spectrographic Analysis feels it desirable to issue a new edition of this symposium which was published in 1935. The six technical papers cover various methods of procedure applicable for a wide variety of materials and are being revised by the committee which will also incorporate considerable added material. Estimated to include 64 pages the publication date is September 15.

Tables of Data on Corrosion and Heat-Resistant Alloys

For many months Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, through its subcommittee on classification of data, has had eight subgroups on various types of stainless steels correlating and recording data on the properties of these materials. The objective is a publication to give up-to-date information on alloys which have had reasonably extensive use, publication to be patterned somewhat after the one issued in 1930. It is hoped that this publication with numerous charts and tables aggregating about 36 pages will be issued in September.

Special Compilations of Standards

As indicated, the development and widespread distribution of so-called special compilations of standards has been one of the very notable publication developments in recent years. Each of the compilations is sponsored by a standing committee of the Society and in selecting material for inclusion the committee officers attempt to provide a complete group of A.S.T.M. standards which would be of service to those concerned with the production and use of the materials covered.

A list of these standards publications which will be issued this year follows, with the designation of the committee responsible indicated. Scheduled month of publication is subject to change. It will be noted that a number are expected to be off press before the Book of Standards, while the balance are listed for completion in December.

One of the very important functions of these publications in addition to supplying all of the A.S.T.M. standards in a specific field in their latest approved form is to furnish through special reports and appendices related information that is of much value to those who use the book. Publications which include considerable supplementary material of this kind are those on refractories, electrical insulating materials, and textile materials.

Compilation	Publication Date	Number of Pages
Steel Piping Standards (A-1)	September	175
Electrical Heating and Resistance Alloys (B-4)	September	135
Copper and Copper Alloys (B-5)	December	400
Cement (C-1)	September	125
Refractories (C-8)	December	200
Mineral Aggregates (C-9—D-4)	December	165
Paint, Varnish and Related Materials (D-1)	December	415
Petroleum Products and Lubricants (D-2)	September	440
Coal and Coke (D-5)	September	140
Electrical Insulating Materials (D-9)	September	450
Rubber Products (D-11)	December	320
Soap (D-12)	December	130
Textile Materials (D-13)	September	440

The complete list of A.S.T.M. publications to be mailed to members in September with the special members' order blank will include some further details of these special compilations and will indicate the members' prices, which range from $1 to $1.75. Special prices are in effect on orders in quantity.

Specifications Branch, Conservation Division

Under the reorganized War Production Board, the Bureau of Industrial Conservation is now termed the Conservation Division, and recently the Specifications Branch of this division has undergone some changes which establish six sections under the following chiefs: Architectural and Codes Section, H. H. Waples; Chemical Section, W. H. Gardner; Civil Engineering Section, C. A. Willson; Electrical and Mechanical Section, Dean Harvey; Metals Section, C. S. Cole; National Emergency Steel Specifications, Edwin Joyce. The titles of the sections indicate generally the problems covered, but the Electrical and Mechanical Section includes in its responsibilities work in the field of paper, textiles and containers, while the Chemical Section covers rubber, paint and varnish, plastics, and the broad range of organic and inorganic chemicals.

One of the functions of the Specifications Branch headed by C. L. Warwick, is to represent the War Production Board in the activities of the Federal Specification Committees. For this purpose, N. F. Harriman, Technical Assistant to the Director of Procurement and Vice-Chairman of the Federal Specifications Executive Committee, has designated the Chief of the Specifications Branch, as *ex-officio* member of each federal specification committee, who in turn has designated various members of the staff of the Specifications Branch to serve on each of the some 70 committees.

Scientific and Technical Societies Handbook

Recently issued by the National Research Council, Washington, D. C., is the "Handbook of Scientific and Technical Societies and Institutions of the United States and Canada" which lists those organizations in natural science and related fields that contribute to the advancement of knowledge. Beginning with the Academy of Medicine of Cincinnati and ending with the Zoological Society of San Diego there are listed 1269 organizations (including A.S.T.M.) in the United States with brief history, object, information on membership, meetings, and publications; the officers and headquarters addresses are also given. There is a Canadian section which lists 143 societies and associations in Canada. This is the fourth edition of this publication. A $4 investment in the Handbook makes conveniently available for reference in anyone's office a great wealth of up-to-date and condensed information on the societies and institutions covered.

New and Revised Tentative Standards Approved

Withdrawals Listed for Members' Convenience

THE SOCIETY accepted at the annual meeting 68 new tentative standards and revisions of 61 existing tentative specifications and methods of test. Of the new tentative standards 8 are revisions of or supplements to existing standards—these are indicated in the following list. Ten of the 61 revised tentative specifications and test methods represent extensive modifications. The titles of these are included below (marked with an asterisk) with the list of those issued by the Society for the first time. Standing committees responsible for the various items are indicated in italics.

New and Revised Tentative Standards

Steel

(Committee A-1)

Specifications:
Welded Alloyed Open-Hearth Iron Pipe (A 253 – 42 T).
Copper Brazed Steel Tubing (A 254 – 42 T).
Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 42 T) (reversion of standard to tentative as revised).

Cast Iron

(Committee A-3)

Methods:
Compression Testing of Cast Iron (A 256 – 42 T).
Definitions:
*Terms Relating to Cast Iron (A 196 – 42 T).

Copper Wire

(Committee B-1)

Specifications:
Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members for Electrical Conductors (B 172 – 42 T).
Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members for Electrical Conductors (B 173 – 42 T).
Bunch-Stranded Copper Conductors for Electrical Conductors (B 174 – 42 T).

Electrical Resistance Alloys

(Committee B-4)

Specifications:
Round Nickel Wire for Lamps and Electronic Devices (B 175 – 42 T).
Methods:
*Nickel and Nickel-Alloy Wire and Ribbon for Electronic Tube Filaments (B 118 – 42 T).
*Lateral Wire for Grids of Electronic Devices (B 156 – 42 T).

Chemical Analysis of Metals

(Committee E-3)

Methods:
Chemical Analysis of Aluminum and Aluminum Alloys (E 34 – 42 T).
Chemical Analysis of Magnesium and Magnesium Alloys (E 35 – 42 T).
Chemical Analysis of Brass (E 36 – 42 T).
Chemical Analysis of Pig Lead (E 37 – 42 T).
Chemical Analysis of Nickel-Chromium Alloys for Electrical Heating (E 38 – 42 T).
Chemical Analysis of Nickel (E 39 – 42 T).
Chemical Analysis of Slab Zinc (E 40 – 42 T).

Cement

(Committee C-1)

Specifications:
Treated Portland Cement for Concrete Pavements (C 175 – 42 T).

Concrete

(Committee C-9)

Specifications:
Waterproof Paper for Curing Concrete (C 171 – 42 T).

Methods:
Sampling Fresh Concrete (C 172 – 42 T).
Test for Air Content of Freshly Mixed Concrete (C 173 – 42 T).
Measuring Length of Drilled Concrete Cores (C 174 – 42 T).

Brick

(Committee C-15)

Method:
Test for Initial Rate of Absorption (Suction) of Brick (C 67 – 42 T), supplement to Standard C 67 – 41.

Refractories

(Committee C-8)

Specifications:
Fireclay Plastic Refractories for Boiler Furnaces and Incinerator Service (C 176 – 42 T).

Thermal Insulating Materials

(Committee C-16)

Method:
Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate (C 177 – 42 T), developed by the Joint Committee on Thermal Conductivity of All Forms of Insulation sponsored by the A.S.H.V.E., A.S.T.M., A.S.R.E., and N.R.C.

Pigments and Paint Materials

(Committee D-1)

Specifications:
Basic Sulfate White Lead (D 82 – 42 T) (reversion of standard to tentative as revised).
Chrome Yellow and Chrome Orange (D 211 – 42 T) (reversion of standard to tentative as revised).
C. P. Toluidine Toner (D 656 – 42 T).
Isopropyl Acetate (D 657 – 42 T).
Methods:
Test for Abrasion Resistance of Organic Coatings with the Air Blast Abrasion Tester (D 658 – 42 T).
Evaluating Degree of Chalking of Exterior Paints of the Linseed Oil Type (D 659 – 42 T).
Evaluating Degree of Checking of Exterior Paints of the Linseed Oil Type (D 660 – 42 T).
Evaluating Degree of Cracking of Exterior Paints of the Linseed Oil Type (D 661 – 42 T).
Evaluating Degree of Erosion of Exterior Paints of the Linseed Oil Type (D 662 – 42 T).
Test for Consistency of Exterior House Paints and Enamel Type Paints (D 562 – 42 T) (reversion of standard to tentative as revised).
Test for Spectral Characteristics and Color of Objects and Materials (D 307 – 42 T) (reversion of standard to tentative as revised).

Petroleum Products and Lubricants

(Committee D-2)

Methods:
Test for Neutralization Number of Petroleum Products by Color-Indicator Titration (D 663 – 42 T).
Test for Neutralization Number of Petroleum Products by Electrometric Titration (D 664 – 42 T).
Test for Rust-Preventing Characteristics of Steam-Turbine Oil in the Presence of Water (D 665 – 42 T).
Conversion of Kinematic Viscosity to Saybolt Furol Viscosity (D 666 – 42 T).
*Test for Knock Characteristics of Motor Fuels (D 357 – 42 T).
*Test for Knock Characteristics of Aviation Fuels (D 614 – 42 T).
*Test for Saponification Number of Petroleum Products by Color-Indicator Titration (D 94 – 42 T).

Road and Paving Materials

(Committee D-4)

Method:
Test for Abrasion of Gravel by Use of the Deval Machine (D 289 – 42 T) (reinstatement of tentative standard).

Paper

(Committee D-6)

Methods:
Conditioning Paper and Paper Products for Testing (D 585 – 42 T).
Qualitative Examination of Mineral Filler and Mineral Coating of Paper (D 686 – 42 T).

Quantitative Determination of Coating on Mineral-Coated Paper (D 687 – 42 T).
Test for Pentosans in Paper (D 688 – 42 T).
Test for Internal Tearing Resistance of Paper (D 689 – 42 T).

Roofing and Waterproofing Materials

(Committee D-8)

Specifications:
Coal-Tar Pitch for Steep Built-Up Roofs (D 654 – 42 T).
Asphalt-Saturated and Asphalt-Coated Asbestos Felts for Use in Constructing Built-Up Roofs (D 655 – 42 T).
Asphalt-Saturated Asbestos Felts for Use in Waterproofing and in Constructing Built-Up Roofs (D 250 – 42 T) (reversion of standard to tentative as revised).

Electrical Insulating Materials

(Committee D-9)

Methods:
Test for Steatite Used as Electrical Insulation (D 667 – 42 T).
Measuring Dimensions of Rigid Tubes Used in Electrical Insulation (D 668 – 42 T).
Test for Power Factor and Dielectric Constant Parallel with Laminations of Laminated Sheet and Plate Insulating Materials (D 669 – 42 T).
Test for Sludge Formation in Mineral Transformer Oil (D 670 – 42 T).
*Testing Vulcanized Fiber Used for Electrical Insulation (D 619 – 42 T).
*Test for Tensile Strength of Molded Electrical Insulating Materials (D 651 – 42 T).

Rubber

(Committee D-11)

Method:
Test for Indentation of Rubber by Means of the Durometer (D 676 – 42 T).

Soaps

(Committee D-12)

Specifications:
Built Soap, Powdered (Type D) (D 533–42 T) (supplement to standard).
Compound Chip Soap (with Rosin) (D 690 – 42 T).
Compound Powdered Soap (Granulated, with Rosin) (D 691 – 42 T).

Textiles

(Committee D-13)

Specifications:
Asbestos Cloth (D 677 – 42 T).
Finished, All-Cotton, Upholstery Tapestries (D 678 – 42 T).
Methods:
Tests and Tolerances for Certain Fine Staple Cotton Gray Goods (D 679 – 42 T).
Tests and Tolerances for Certain All-Cotton and Cotton-and-Rayon Fine Fancy Goods (D 680 – 42 T).
Tests and Tolerances for Jute Rove and Plied Yarn for Electrical and Packing Purposes (D 681 – 42 T).
Test for Colorfastness to Atmospheric Gases of Dyed Cellulose Acetate Rayon (D 682 – 42 T).
Test for Identification of Finishes on Textiles (D 683 – 42 T).
Test for Resistance of Textile Fabrics to Microorganisms (D 684 – 42 T).
*Tests and Tolerances for Certain Wool and Part Wool Fabrics (D 462 – 42 T).
*Quantitative Analysis of Textiles (D 629 – 42 T).

Plastics

(Committee D-20)

Methods:
Repeated Flexural Stress (Fatigue) Test of Plastics (D 671 – 42 T).
Test for Haze of Transparent Plastics by Photoelectric Cell (D 672 – 42 T).
Test for Mar Resistance of Plastics (D 673 – 42 T).
Recommended Practice:
Long-Time Tension Tests of Plastics (D 674 – 42 T).
Classification:
Terms and Descriptive Nomenclature of Objects Made from Plastics (D 675 – 42 T).

Standards and Tentative Standards Withdrawn and Replaced

At the annual meeting the Society accepted recommendations from the standing committees for the withdrawal of the following five standards and two tentative standards:

Specifications:
Lock-Bar Steel Pipe (A 137 – 34).
Carbon-Steel Bars for Vehicle and General Purpose Springs (A 58 – 27).
Cast-Iron Locomotive Cylinders (A 45 – 14).
Chilled-Tread Cast-Iron Wheels (A 46 – 30 T).
Asphalt Roofing Surfaced with Fine Mineral Granules (D 248 – 41 T).
Methods:
Test for Voids in Inundated Fine Aggregate (C 69 – 30).
Test for Estimating Hard Scoured Wool in Wool in the Grease (Mill Scale Operations) (D 232 – 36).

In addition to the above, 10 standards and 8 tentative standards have been replaced by new or revised specifications and tests. Listed below are the titles of these standards and tentative standards which are now obsolete, together with references to the designations of the new tentative specifications or tests replacing them.

Specifications:
Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 41), replaced by new Tentative Specifications A 106 – 42 T.
Rope-Lay-Stranded and Bunch-Stranded Copper Cables for Electrical Conductors (B 158 – 41 T), replaced by new Tentative Specifications B 172 – 42 T, B 173 – 42 T, B 174 – 42 T.
Muntz Metal Condenser Tube Plates (B 57 – 27), replaced by new Tentative Specifications B 171 – 42 T.
Ready Mixed Concrete (C 94 – 38) replaced by new Tentative Specifications C 94–42 T.
Basic Sulfate White Lead (D 82 – 41) replaced by new Tentative Specifications D 82 – 42 T.
Chrome Yellow (D 211 – 41), replaced by new Tentative Specifications D 211 – 42 T.
Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs (D 250 – 27), replaced by new Tentative Specifications D 250 – 42 T.
Methods:
Test for Neutralization Number of Petroleum Products and Lubricants (D 188–41 T), replaced by new Tentative Methods D 663 – 42 T, and D 664 – 42 T.
Testing Molded Materials Used for Electrical Insulation (D 48 – 39), replaced by new Tentative Method D 48 – 41 T.
Test for Impact Resistance of Electrical Insulating Materials (D 256 – 38), replaced by new Tentative Method D 256 – 41 T.
Test for Spectral Apparent Reflectivity of Paints (D 307 – 39), replaced by new Tentative Methods D 307 – 42 T.
Test for Consistency of Enamel Type Paints (D 562 – 41), replaced by new Tentative Methods D 562 – 42 T.
Chemical Analysis of Pig Lead (B 35 – 36 T), replaced by new Tentative Methods E 37 – 42 T.
Chemical Analysis of Slab Zinc (B 38 – 36 T), replaced by new Tentative Methods E 40 – 42 T.
Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 36 T), replaced by new Tentative Methods E 34 – 42 T.
Chemical Analysis of Nickel (B 41 – 36 T), replaced by new Tentative Methods E 39 – 42 T.
Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 36 T), replaced by new Tentative Methods E 36 – 42 T.
Chemical Analysis of Metallic Materials for Electrical Heating (B 71 – 34 T), replaced by new Tentative Methods E 38 – 42 T.

Full details of all of the actions affecting the standards and tentative standards are given in the Summary of Proceedings which is being sent to each member in a separate mailing.

Discussion of Annual Meeting Papers

WRITTEN DISCUSSION of the papers and reports presented at the 1942 Annual Meeting in Atlantic City will be received by the Committee on Papers and Publications until September 1. However, all who plan to submit discussion are urged to send it to Society Headquarters as far in advance of this date as possible in order to facilitate preparation of material for the *Proceedings*. Discussion adds considerably to the value of the technical material published in the *Proceedings*, and all those who may have additional material to submit, or wish to offer constructive comments, are urged to do so.

SAE-ASTM Classifications and Tests Recommended for Natural Rubber and Synthetic Rubber Compounds

TECHNICAL COMMITTEE A on Automotive Rubber, which is sponsored jointly by the Society of Automotive Engineers and the A.S.T.M. and which functions as a subcommittee of A.S.T.M. Committee D-11, has recently presented to the sponsors two sets of classifications and test requirements for rubber, one for natural rubber stocks, the other for synthetic rubber compounds. These classifications are an important contribution to the war effort. The main objective of this program was the conservation of rubber by means of restriction of specifications. During the course of work it was agreed by all those concerned that the number of rubber specifications could be very largely reduced so as to simplify the rubber compounding problem. It was decided to draw up specifications for rubber stock which would cover the whole range of properties needed in manufacturing rubber articles. The committee plans to study and investigate the suitability of these classifications for special applications. It is hoped that these specifications will be followed as closely as possible by the automotive, aeronautical, mechanical, and allied industries.

The SAE-ASTM Classification for Synthetic Rubber Stocks has been compiled by Subcommittee V on Standardization of Synthetic Rubber Specifications under the chairmanship of J. H. Doering, Ford Motor Co., with J. V. Hendrick, Chrysler Corporation, secretary. This is recommended for automotive and aeronautical applications. These specifications are timely in view of the many critical applications in which synthetic rubber will now need to be used, in place of natural rubber compounds.

The SAE-ASTM Classification for Natural Automotive Rubbers was prepared by Subcommittee IV on Rubber Conservation the officers of which are W. J. McCortney, chairman, and J. C. Dudley, secretary, both with the Chrysler Corporation. This classification, shown in the accompanying table, is recommended for use in automotive and general mechanical applications other than tires, for absorbing noise or vibration, or where resiliency is required. The requirements listed represent a careful selection from several hundred natural rubber stocks that have been in use, and the data listed have been derived from information available in both the rubber and mechanical industries. As will be noted, the requirements forming the basis of the classification are based upon A.S.T.M. methods, which will also provide a uniformity in testing.

Both of these classifications will be subject periodically to revisions considered necessary as a result of further developments and experience.

S.A.E.-A.S.T.M. Classifications Recommended for Synthetic Rubbers

CLASSIFICATIONS

For the past four months Subcommittee V on Synthetic Rubber Specifications of the S.A.E.-A.S.T.M. Technical Committee A on Automotive Rubber, has been working on the standardization of specifications for synthetic rubber.

After due consideration, the subcommittee has concluded that, basically, synthetic rubbers could best be described by grouping them in three classifications. These classifications would depend upon their relative change in volume after immersion in a chosen test fluid.

Every classification is identified by two letters, followed by three numerals. The first letter is S (standing for "synthetic") followed by A, B, or C depending upon the grouping as just described. Each classification (A, B, or C) is further subdivided depending upon the A.S.T.M. hardness and the original tensile strength. The first numeral refers to Shore durometer hardness (3 for 25 to 35 durometer range, 150 A.S.T.M. hardness; 4 for 35 to 45 durometer range, 105 A.S.T.M. hardness, etc.), the next two numerals refer to the tensile strength (06 standing for 600 psi., etc.). Thus SA-607 represents a synthetic rubber composition of classification A having a Shore durometer hardness of 55 to 65 (55 A.S.T.M. hardness), and a minimum original tensile strength of 700 psi. In classifications B and C appear classification numbers ending in 00. These refer to compositions designed for low compression set; the tensile strength and elongation are not specified.

In addition to the original tensile strength and hardness, the tests shown in Tables A, B, and C are necessary to correctly specify common synthetic rubber compositions. These additional tests (described later in the section on Testing Procedure) consist of the measurement of the elongation and the compression set; the changes in tensile strength, elongation, and hardness after oven aging; and changes in tensile strength, durometer hardness, and volume change after oil aging.

These tests are performed in accordance with A.S.T.M. standard and tentative methods with the exceptions described later. The committee believes that these exceptions are necessary for the testing of synthetic rubber compositions, but not necessary for the testing of natural rubber vulcanizates. These variations from standard A.S.T.M. testing methods were made for the following reasons:

Compression Set (A.S.T.M. D 395 – 40 T, Method B).—In the interest of uniformity in testing, a definite deflection has been specified for each hardness range. The A.S.T.M. method allows a deflection range for each hardness range.

Oven Aging (A.S.T.M. D 573 – 41).—For classifications B and

TABLE A.—S.A.E.-A.S.T.M. SYNTHETIC RUBBER SPECIFICATION STANDARDS CLASSIFICATION A.
(See S.A.E.-A.S.T.M. Modified Testing Procedure for Methods of Testing)

Classification Number	A.S.T.M. Hardness	Approximate Shore Durometer Hardness	Tensile Strength, min., psi.	Elongation, min., per cent	Compression Set, max., per cent	Oven Aged			Oil Aged		
						Tensile Strength, per cent Change	Elongation, per cent Change	Durometer Hardness, Points Change Limits	Volume, per cent Change Limits	Tensile Strength, per cent Change	Durometer Hardness, Points Change Limits
SA-302	150 ± 20	30	200	500	no test	no test	no test	no test	−15 to 5	−20	−5 to 10
SA-403	105 ± 15	40	300	500	no test	no test	no test	no test	− 5 to 3	−20	−5 to 5
SA-506	75 ± 10	50	600	500	no test	no test	no test	no test	− 3 to 3	−20	−5
SA-607	55 ± 8	60	700	400	no test	no test	no test	no test	− 3 to 3	−20	−5
SA-706	40 ± 7	70	600	400	no test	no test	no test	no test	− 3 to 3	−20	−5
SA-709	40 ± 7	70	900	300	no test	no test	no test	no test	− 3 to 3	−20	−5
SA-809	28 ± 7	80	900	200	no test	no test	no test	no test	− 3 to 3	−20	−5
SA-910	13 ± 7	90	1000	100	no test	no test	no test	no test	− 3 to 3	−20	−5

TABLE B.—S.A.E.-A.S.T.M. SYNTHETIC RUBBER SPECIFICATION STANDARDS CLASSIFICATION B.
(See S.A.E.-A.S.T.M. Modified Testing Procedure for Methods of Testing)

Classification Number	A.S.T.M. Hardness	Approximate Shore Durometer Hardness	Tensile Strength, min., psi.	Elongation, min., per cent	Compression Set, max., per cent (Method B)	Oven Aged			Oil Aged		
						Tensile Strength, per cent Change	Elongation, per cent Change	Durometer Hardness, Points Change Limits	Volume, per cent Change Limits	Tensile Strength, per cent Change	Durometer Hardness, Points Change Limits
SB-305	150 ± 20	30	500	400	50	−20	−50	0 to 20	−15 to 25	−20	−10 to 20
SB-309	150 ± 20	30	900	500	50	−20	−50	0 to 20	−15 to 25	−20	−10 to 20
SB-405	105 ± 15	40	500	400	45	−20	−50	0 to 20	−15 to 25	−20	−10 to 20
SB-410	105 ± 15	40	1000	500	45	−20	−50	0 to 20	−15 to 25	−20	−10 to 20
SB-415	105 ± 15	40	1500	500	45	−20	−50	0 to 15	−15 to 25	−20	−10 to 15
SB-400	105 ± 15	40	..	...	25	..	..	0 to 15	−15 to 25	..	−10 to 15
SB-508	75 ± 10	50	800	400	40	−20	−50	0 to 15	− 5 to 25	−20	−10 to 15
SB-515	75 ± 10	50	1500	500	40	−20	−50	0 to 15	− 5 to 25	−20	−10 to 15
SB-520	75 ± 10	50	2000	500	40	−20	−50	0 to 10	− 5 to 25	−20	−10 to 10
SB-500	75 ± 10	50	..	...	25	..	..	0 to 10	− 5 to 25	..	−10 to 10
SB-608	55 ± 8	60	800	300	35	−20	−60	0 to 15	− 5 to 25	−20	−10 to 10
SB-617	55 ± 8	60	1700	400	35	−20	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-625	55 ± 8	60	2500	500	35	−20	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-600	55 ± 8	60	..	...	25	..	..	0 to 10	− 5 to 25	..	−10 to 10
SB-710	40 ± 7	70	1000	300	30	−20	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-720	40 ± 7	70	2000	300	30	−60	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-730	40 ± 7	70	3000	400	30	−20	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-700	40 ± 7	70	..	...	25	..	..	0 to 10	− 5 to 25	..	−10 to 10
SB-804	28 ± 7	80	400	100	30	−20	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-810	28 ± 7	80	1000	150	30	−20	−60	0 to 10	− 5 to 25	−20	−10 to 10
SB-820	28 ± 7	80	2000	150	30	−20	−60	0 to 10	− 5 to 25	−20	−10 to 5
SB-902	13 ± 7	90	200	50	40	−20	−60	0 to 5	− 5 to 25	−20	−10 to 5
SB-910	13 ± 7	90	1000	100	30	−20	−60	0 to 5	− 5 to 25	−20	−10 to 5

TABLE C.—S.A.E.-A.S.T.M. SYNTHETIC RUBBER SPECIFICATION STANDARDS CLASSIFICATION C.
(See S.A.E.-A.S.T.M. Modified Testing Procedure for Methods of Testing)

Classification Number	A.S.T.M. Hardness	Approximate Shore Durometer Hardness	Tensile Strength, min., psi.	Elongation, min., per cent	Compression Set max., per cent (Method B)	Oven Aged			Oil Aged		
						Tensile Strength, per cent Change	Elongation, per cent Change	Durometer Hardness, Points Change Limits	Volume, per cent Change Limits	Tensile Strength, per cent Change	Durometer Hardness, Points Change Limits
SC-305	150 ± 20	30	500	500	70	−15	−40	15	100 to 150	−75	−30 to −10
SC-310	150 ± 20	30	1000	500	70	−15	−40	15	100 to 150	−75	−30 to −10
SC-320	150 ± 20	30	2000	500	70	−15	−40	15	100 to 150	−75	−30 to −10
SC-405	105 ± 15	40	500	500	65	−15	−40	15	90 to 140	−70	−35 to −15
SC-415	105 ± 15	40	1500	500	65	−15	−40	15	90 to 140	−70	−35 to −15
SC-425	105 ± 15	40	2500	500	65	−15	−40	15	90 to 140	−70	−35 to −15
SC-400	105 ± 15	40	...	...	20	..	..	15	90 to 140	..	−35 to −15
SC-507	75 ± 10	50	700	300	60	−15	−40	15	80 to 130	−60	−40 to −20
SC-512	75 ± 10	50	1200	300	60	−15	−40	15	80 to 130	−60	−40 to −20
SC-520	75 ± 10	50	2000	400	60	−15	−40	15	80 to 130	−60	−40 to −20
SC-530	75 ± 10	50	3000	500	60	−15	−40	15	80 to 130	−60	−40 to −20
SC-500	75 ± 10	50	...	...	20	..	..	15	80 to 130	..	−40 to −20
SC-608	55 ± 8	60	800	300	55	−15	−40	15	70 to 120	−50	−50 to −20
SC-614	55 ± 8	60	1400	300	55	−15	−40	10	70 to 120	−50	−50 to −20
SC-620	55 ± 8	60	2000	300	55	−15	−40	10	70 to 120	−50	−50 to −20
SC-630	55 ± 8	60	3000	400	55	−15	−40	10	70 to 120	−50	−50 to −20
SC-600	55 ± 8	60	...	...	20	..	..	10	70 to 120	..	−50 to −20
SC-707	40 ± 7	70	700	200	50	−15	−40	10	60 to 110	−50	−50 to −25
SC-717	40 ± 7	70	1700	200	50	−15	−40	10	60 to 110	−50	−50 to −25
SC-725	40 ± 7	70	2500	300	50	−15	−40	10	60 to 110	−50	−50 to −25
SC-700	40 ± 7	70	...	...	20	..	..	10	60 to 110	..	−50 to −25
SC-804	28 ± 7	80	400	100	50	−15	−40	10	50 to 100	−30	−50 to −30
SC-808	28 ± 7	80	800	100	50	−15	−40	10	50 to 100	−30	−50 to −30
SC-815	28 ± 7	80	1500	100	50	−15	−40	10	50 to 100	−30	−50 to −30
SC-902	13 ± 7	90	200	50	50	−15	−40	5	40 to 90	−30	−50 to −30
SC-910	13 ± 7	90	1000	100	50	−15	−40	5	40 to 90	−30	−50 to −30

C a temperature of 100 C, is preferable to the standard 70 C., because the higher test temperature more closely approximates service temperatures for these classifications.

The A.S.T.M. method does not specify a definite time interval. Since an economy of testing time is desirable, the committee suggests a 70-hr. period. This amounts to a 3-day test, less 2 hr., which allows sufficient time, during the working day, for inspection of samples after aging.

Oil Aging (A.S.T.M. D 471 - 40 T).—The temperatures suggested by the committee are allowed in the A.S.T.M. method. The special aging period was selected for the reasons given in the preceding paragraph.

The immersion medium described by the requirements for *aniline point* and *viscosity* is readily available. Conformity to the aniline point range is important since this constant predicts the swelling power of the oil. The oil described represents a fluid having the probable maximum swelling power of common commercial petroleum-derived oils.

In the A.S.T.M. method the tensile strength after immersion is calculated by means of an A.S.T.M. formula which is a combined function of volume change, after immersion, and the aged tensile strength based on the original cross-sectional area of the test specimen. To prevent erroneous conclusions, the committee feels that this formula should be deleted and the tensile strength after oil aging be calculated on the basis of the original unaged cross-sectional area. This is particularly important in the case of compositions which may suffer a decrease in volume as a result of oil immersion.

The proposed tests and limits form primary specifications and are intended merely to describe common synthetic rubber compositions. Undoubtedly, additional requirements will be needed to adequately specify synthetic rubber for special service applications, such as those involving resistance to aromatic fuels, flexing, stiffening at low temperatures, ozone, etc.

It, therefore, will be the further function of Subcommittee V to investigate and develop suitable test methods for these special requirements. The additional special tests to be considered by the committee are for:

1. Low temperature to −70 F.,
2. High temperature to +350 F.,
3. Aromatic fuels,
4. Anti-freeze and coolant,
5. Extraction,
6. Ozone,
7. Weather—ultraviolet,
8. Flame,
9. Tear,
10. Abrasion,
11. Flexing, and
12. Product application.

TESTING PROCEDURES

1. *A.S.T.M. Hardness.*—Standard Method of Test for Hardness of Rubber (A.S.T.M. Designation: D 314 − 39).[1]

2. *Tensile Strength and Elongation.*—Standard Methods of Tension Testing of Vulcanized Rubber (A.S.T.M. Designation: D 412 − 41).[2]

3. *Compression Set.*—Tentative Methods of Test for Compression Set of Vulcanized Rubber (A.S.T.M. Designation: D 395 − 40 T),[3] Method B with the following exceptions:

Deflections of various hardness to be limited in accordance with Table I.

TABLE I.

Durometer Hardness	Deflection, per cent of Original Thickness
30	40
40	40
50	30
60	30
70	25
80	25
90	25

4. *Oven Aging.*—Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method (A.S.T.M. Designation: D 573 − 41),[4] with the following exceptions:

	Test Conditions
Classification A	70 hr. at 70 C.
Classifications B and C	70 hr. at 100 C.

5. *Oil Aging.*—Tentative Methods of Test for Changes in Properties of Rubber and Rubber-Like Materials in Liquids (A.S.T.M. Designation: D 471 − 40 T),[5] with the following exceptions:

	Test Conditions
(*a*) Classification A	70 hr. at 70 C.
Classifications B and C	70 hr. at 100 C.
(*b*) Oil to be rubber process type:	
Aniline point[a]	70 ± 2 C.
Viscosity, Saybolt Universal[b]	155 ± 5 sec. at 100 F.
(*c*) Tensile Strength: Delete tensile strength − volume formula under Section 10 (*c*) and base calculations on original unaged cross-sectional area.	

[1] 1939 Book of A.S.T.M. Standards, Part III, p. 347.

[2] 1941 Supplement to Book of A.S.T.M. Standards, Part III, p. 69.

[3] 1940 Supplement to Book of A.S.T.M. Standards, Part III, p. 332.

[4] 1941 Supplement to Book of A.S.T.M. Standards, Part III, p. 81.

[5] 1940 Supplement to Book of A.S.T.M. Standards, Part III, p. 327.

[a] Tentative Method of Test for Aniline Point of Petroleum Products (D 611 − 41 T), 1941 Supplement to A.S.T.M. Standards, Part III, p. 257.

[b] Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (D 88 − 38) 1939 Book of A.S.T.M. Standards, Parts II and III.

S.A.E.-A.S.T.M. Classification of Natural Rubber Qualities for Automotive Use

Use:

Prefix letter "R" of classification number indicates "Rubber."

Suffix letter "A"* indicates general purpose rubber compounds for which compression set or special aging is not required or designated.

Suffix letter "B"* indicates rubber compounds with maximum compression set requirements.

Suffix letter "C"* indicates rubber compounds adapted for outdoor aging.

Physical Properties specified in the tables are based on test specimens having an equivalent cure of the part in question rather than the optimum cure and the physical properties of the part correlated with the test specimens.

Hardness:

First digit of the Classification Number indicates the approximate durometer hardness.

The A.S.T.M. hardness specified shall be determined in

* These suffix letters may be used singly or in combination, as applying to any of the rubber stocks listed in the classification, depending upon requirements.

accordance with the A.S.T.M. Standard Method of Test for Hardness of Rubber (D 314 – 39).[1]

Tensile Strength:

Second and third digits of the Classification Number indicate minimum tensile strength.

The tensile strength and elongation specified shall be determined in accordance with the A.S.T.M. Standard Methods of Tension Testing of Vulcanized Rubber (D 412 – 41).[2]

Load Deflection:

The load deflection specified shall be determined in accordance with the A.S.T.M. Tentative Methods of Test for Compression-Deflection Characteristics of Vulcanized Rubber (D 575 – 40 T).[3]

Compression Set:

On compounds R300 B, R400 B, R500 B, R600 B, and R700 B the compression set shall not exceed 25 per cent. When the "B" designation is used on any other compound, the compression set shall not exceed 50 per cent.

Attention is called to the new A.S.T.M. Tentative Methods of Test for Compression Set of Vulcanized Rubber (D 395 – 40 T)[4] (Method B) which is based on compressed thickness of specimen rather than the original thickness. Maximum compression set specified shall be determined by the new method.

Research is in progress on the use of other limits of time and temperature. As a reference check, A.S.T.M. test procedure D 395 – 40 T (Method B) may be extended to 70 hr. with comparable limits of compression set.

Aging:

Tensile strength and elongation deteriorations shall not exceed 15 per cent of original values of any compounds after 72 hr. at 158 F., when determined in accordance with the A.S.T.M. Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method (D 573 – 41).[5]

[1] 1939 Book of A.S.T.M. Standards, Part III, p. 347.
[2] 1941 Supplement to Book of A.S.T.M. Standards, Part III, p. 69.
[3] 1940 Supplement to Book of A.S.T.M. Standards, Part III, p. 338.
[4] 1940 Supplement to Book of A.S.T.M. Standards, Part III, p. 332.
[5] 1941 Supplement to Book of A.S.T.M. Standards, Part III, p. 61.

Color:

Color is not specified in any of these classifications, but should be black whenever possible and without bloom that may have an adverse effect on the aging of the compound.

S.A.E.-A.S.T.M. CLASSIFICATION OF NATURAL RUBBER QUALITIES FOR AUTOMOTIVE USE.

Classification Number	Hardness, A.S.T.M. Method D 314 – 39[a]	Tensile Strength, min., psi., A.S.T.M. Method D 412 – 41[a]	Elongation, min., per cent A.S.T.M. Method D 412 – 41[a]	20 per cent Load Deflection, psi., A.S.T.M. Method D 575 – 40 T[a]	Hardness, Shore Durometer (Approximate), A.S.T.M. Method D 676 – 42 T[a]
R300 B	150 ± 20	...	...	.....	30
R309	150 ± 20	900	500	.....	30
R315	150 ± 20	1500	600	70 ± 10	30
R320	150 ± 20	2000	600	70 ± 10	30
R330	150 ± 20	3000	700	70 ± 10	30
R400 B	105 ± 15	...	...	.....	40
R405	105 ± 15	500	300	.....	40
R409	105 ± 15	900	500	.....	40
R415	105 ± 15	1500	500	100 ± 15	40
R420	105 ± 15	2000	500	100 ± 15	40
R430	105 ± 15	3000	600	100 ± 15	40
R500 B	75 ± 10	...	...	.....	50
R506	75 ± 10	600	300	.....	50
R509	75 ± 10	900	300	.....	50
R515	75 ± 10	1500	400	140 ± 20	50
R525	75 ± 10	2500	500	140 ± 20	50
R535	75 ± 10	3500	600	140 ± 20	50
R600 B	55 ± 8	...	...	.....	60
R606	55 ± 8	600	300	.....	60
R609	55 ± 8	900	300	.....	60
R615	55 ± 8	1500	350	195 ± 30	60
R620	55 ± 8	2000	400	195 ± 30	60
R625	55 ± 8	2500	450	195 ± 30	60
R635	55 ± 8	3500	550	195 ± 30	60
R700 B	40 ± 7	...	...	.....	70
R703	40 ± 7	300	100	.....	70
R704	40 ± 7	400	150	.....	70
R706	40 ± 7	600	200	.....	70
R709	40 ± 7	900	250	.....	70
R715	40 ± 7	1500	300	285 ± 50	70
R720	40 ± 7	2000	350	285 ± 50	70
R730	40 ± 7	3000	450	285 ± 50	70
R804	28 ± 7	400	100	.....	80
R806	28 ± 7	600	150	.....	80
R809	28 ± 7	900	200	.....	80
R812	28 ± 7	1200	250	.....	80
R820	28 ± 7	2000	250	450 ± 75	80
R825	28 ± 7	2500	300	450 ± 75	80
R907	13 ± 7	700	75	.....	90
R915	13 ± 7	1500	200	.....	90

[a] These designations refer to the following methods of the American Society for Testing Materials:

Standard Method of Test for Hardness of Rubber (A.S.T.M. Designation: D 314), 1939 Book of A.S.T.M. Standards, Part III, p. 347;
Standard Methods of Tension Testing of Vulcanized Rubber (A.S.T.M. Designation: D 412), 1941 Supplement to Book of A.S.T.M. Standards, Part III, p. 69;
Tentative Methods of Test for Compression-Deflection Characteristics of Vulcanized Rubber (A.S.T.M. Designation: D 575), 1940 Supplement to A.S.T.M. Standards, Part III, p. 338; and
Tentative Method of Test for Indentation of Rubber by Means of the Durometer (A.S.T.M. Designation: D 676), 1942 Book of A.S.T.M. Standards, Part III.

A.S.T.M. Members Asked to Vote on Large Number of Standards

By action of the Forty-fifth Annual Meeting, 178 recommendations from standing committees affecting standards and tentative standards were approved for submission to letter ballot of the Society membership. These recommendations comprise 72 tentative standards proposed for adoption as standard and the adoption as standard of 106 revisions in existing standards.

Throughout the year, Committee E-10 on Standards approves recommendations of standing committees and at the annual meeting sessions there are a large number of actions taken as summarized in the table printed earlier in this Bulletin, *but only by letter ballot of the entire Society membership can actual changes be made in the formal standards* which involves either adoption of a tentative standard as standard, or the adoption of revisions in formal standards. Through the Committee E-10 procedure and the regular annual meeting procedure, new tentative standards can be approved for publication, revisions in these tentatives can be adopted, and tentative revisions of standards for publication can be approved, but none of these involve actual changes in formal standards.

A complete list of the items to be voted upon appears in the letter ballot being sent in a separate mailing to the members. Detailed information concerning most matters referred to letter ballot is given in the committee reports issued in preprint form to the membership in advance of the meeting. The *Summary of Proceedings* accompanying the letter ballot contains a record of all actions taken at the annual meeting and also gives in full detail any changes in or additions to the standing committee recommendations as preprinted.

The ballot will be canvassed on September 1 at which time all items receiving a favorable vote become effective.

More New Emergency Alternate Provisions and Specifications

Emergency Cement and "Braden" Copper Standards

Since the May issue of the Bulletin in which on pages 43 to 53 there were given notes of complete emergency specifications and discussion, with full details, of numerous emergency alternate provisions, a number of additional items have been acted on through the usual Society procedure—that is, approval in a subcommittee and by the chairman of the main standing committee, and then reference to A.S.T.M. Committee E-10 on Standards. In the accompanying table is a list of the provisions issued since April 28. This list, with the one published in the May Bulletin, page 48, provides a complete itemization of those issued.

List of Emergency Alternate Provisions—Issued Since April 28, 1942

Emergency Alternate Designation	Title
	Specifications for:
EA – A 177	High-Strength Corrosion-Resisting Chromium-Nickel Steel Sheet and Strip
EA – A 190	Lightweight and Thin-Sectioned Gray Iron Castings
EA – B 146	Leaded Yellow Brass Sand Castings for General Purposes
EA – D 224	Asphalt Roofing Surfaced with Powdered Talc or Mica
EA – D 249	Asphalt Roofing Surfaced with Coarse Mineral Granules
EA – D 375	Specifications and Methods of Test for Asbestos Roving for Electrical Purposes
EA – D 496	Chip Soap
EA – D 498	Powdered Soap Nonalkaline Soap Powder

Following discussion in subsequent paragraphs of some of the emergency provisions the complete emergency alternate provisions are printed. All of these are being issued as pink slips and in accordance with the regulations are also published in the Bulletin. Some of those printed here are not commented on since the reasons for their issuance were covered in the May Bulletin, at which time complete details of the provisions could not be published. A set of the provisions is furnished to each member (there will be another mailing sometime in July or August) and the purchasers of the Book of A.S.T.M. Standards can obtain on request sets of the provisions in accordance with the number of Books of Standards bought. Additional copies of the provisions are on sale at nominal prices.

Complete Emergency Specifications

Three emergency specifications have been issued as follows:

Emergency Specifications for Rubber Sheath Compound for Electrical Insulated Cords and Cables Where Extreme Abrasion Resistance Is Not Required, ES – 6 (May 8, 1942)

Emergency Specifications for Fire-Refined Copper Other Than Lake, ES – 7 (June 13, 1942)

Emergency Alternate Specifications for Portland Cement, EA – C 150 (June 6, 1942)

It will be noted that the word "alternate" appears in the title of the specifications for portland cement which indicates that there is an existing standard for which the new requirements are alternate, but in the case of the rubber sheath compound and copper there were no existing specifications. The physical requirements for the vulcanized rubber sheath call for a minimum tensile strength of 1800 psi.; elongation at rupture of 350 min.; set in 2-in. gage length, $^3/_8$ in. max.; and a tensile strength after 48 hr. in oxygen bomb test of 1400 min. psi.

The emergency specifications for fire-refined copper other than lake were developed in A.S.T.M. Committee B-2 on Non-Ferrous Metals and Alloys and are a recognition of the desirability of standardizing the requirements for material, a considerable tonnage of which has been imported by the Metal Reserves Co. In the trade this brand of copper is termed "Braden."

This emergency grade of fire-refined copper is intended for alloying in wrought alloys when specifically approved in the applicable A.S.T.M. product specifications. This grade is also intended for use in rolling into sheets and shapes for mechanical purposes; it is not intended for electrical purposes. The chemical composition requirements call for

Copper plus silver, min., per cent	99.83
Arsenic, max., per cent	0.015
Antimony, max., per cent	0.003
Selenium plus tellurium, max., per cent	0.015
Nickel, max., per cent	0.04

The A.S.T.M. product specifications in which this material can be applied are under the charge of Committee B-5 on Copper and Copper Alloys.

The emergency alternate portland cement specifications cover three types, I, II, and III, corresponding to the same types in the existing standard C 150. The low heat of hydration, type IV, and high sulfate resistance, type V, are not covered in the emergency requirements. The specifications permit the addition of TDA in types I and II in amounts not exceeding 0.045 per cent by weight of the cement and in type III in amounts not exceeding 0.08 per cent, and vinsol resin may be added to types I and II in amounts of not less than 0.025 and not more than 0.045 per cent by weight of the cement. The chemical requirements are in line with the existing requirements except that the tricalcium silicate permissible maximum of 50 per cent has been deleted for type II. Physical requirements are markedly different from the standard, autoclave expansion, max., being 1.0 per cent instead of 0.50; the specific surface in square centimeters per gram being specified as minimum and maximum values for any one sample, minimum, 1500, maximum, 2000; and the tensile strength requirements for 1 day in moist air and 2 days and 6 days in water are 150 and 275 psi. min., respectively, for type I; 125 and 250 psi. min. for type II; and for type III, 275 psi. min. for one day in moist air, and 375 for one day in moist air and two days in water. The 27-day test is not covered in the emergency alternate specifications.

These cement specifications were developed in close co-

operation with the Building Materials Branch, Division of Industry Operations, WPB, and the Federal Specifications Executive Committee, and are referred to in an order from the WPB covering the manufacture of cement. J. L. Miner, Vice-President, The Atlas Lumnite Cement Co., has been head of the special A.S.T.M. committee which is responsible for this specification.

A copy of each of these three emergency specifications, ES – 6, ES – 7 and EA – C 150 can be obtained by members on request.

Ferrous Metals

Of the emergency alternate provisions detailed here, it was previously indicated that those covering rails, tie plates, and track bolts were developed in a Technical Advisory Committee functioning under the National Emergency Steel Specifications work, and like all other provisions are in the interest of expediting procurement or conserving critical or strategic materials.[1]

The provisions in the four wheel specifications A 25, A 57, A 186, and A 244 were developed in another TAC on Rails, Wheels, and Ties, the sole change being that the sulfur content of acid steel may be as high as 0.06, compared with the present basic steel top of 0.05 per cent.

The emergency provisions in the axle-steel bars for concrete reinforcement specifications provide a much wider source of supply of basic materials used. It had been proposed in one of the NESS TAC Committees on Reinforcement Steel that an emergency soft grade of steel be covered, but conflicting opinions have postponed any definite action on this matter.

The changes in the corrosion-resisting sheet, strip, and plate specifications A 167, A 177, and A 240 are to bring chemistry in line with current practice and with the scrap situation. Changes in specifications A 240 will tie in with emergency provisions being set up by Committee A-1 on Steel in two of its tubing specifications—A 213 and A 249—in which material conforming to A 240 is used for tube fabrication.

Non-Ferrous Metals

Detailed discussion of reasons prompting the emergency alternate provisions in the various copper and copper-alloy casting specifications B 30, B 60, B 62, B 143, B 144, B 145, B 146, and B 148 were given in the May Bulletin. These were developed in close cooperation with the Federal Specifications Committee and the S.A.E. The emergency chemical compositions are such as to conserve important strategic and critical alloys—tin, copper, etc.—and are accompanied by some changes in physical properties, although the changes are not very appreciable. Reference should be made to page 46, May Bulletin, for discussion of the provisions which appear here in their complete form.

Nonmetallic Materials

It will be noted that the provisions in the Specifications for Asphalt Roofing Surfaced with Powdered Talc or Mica (D 224 – 41 T) and for Asphalt Roofing Surfaced with Coarse Mineral Granules (D 249 – 41 T) provide for the omission of requirements for protective coatings (galvanized or sherardized) on nails.

Reasons for the emergency provisions in the soap specifications D 496 and D 498 were discussed in the May Bulletin and are expected to help in procurement.

[1] It should be noted that in paragraph 3 in Appendix I, Specifications for Open-Hearth Carbon-Steel Rails (EA – A 1) the rail temperature should be 725 and not 700. This is given correctly in this Bulletin, but the pink slip is incorrect. This figure was corrected in later *Proceedings* of the American Railway Engineering Assn.

EA – A 1

Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 39) and affect only the requirements referred to:

Section 5.—Change this section to read as follows:

5. The steel shall conform to the requirements as to chemical composition prescribed in Table I. *However, when specified by the purchaser, heavier weights of rail shall be made to the chemical composition requirements specified for lighter weights of rail.*

Table I.—Change the weight of rail in the heading of the last column of Table I from "121–140" to read "121–152" lb. per yd.

Section 10 (d).—Change the second sentence of this section to read as follows:

These supports shall be spaced 3 ft. between centers for rails 106 lb. per yd. or less in weight; 4 ft. for rails 106 *to 140* lb. per yd. in weight; *and 4 ft. 8 in. for rails over 140 lb. per yd. in weight.*

Section 11 (a).—In the first column of the table under weight of rail change the last item from "121 to 140, incl." to read "121 to 152, incl.," lb. per yd.

Section 13.—Designate this section as Section 13 (*a*) and change the first sentence to read as follows by the addition of the italicized words:

A test specimen representing the top end of the top rail of each ingot of each melt rolled, which has passed the drop test requirements of Section 11, shall be nicked and broken, *unless waived by the purchaser.*

Add a new Paragraph (*b*) to read as follows:

(*b*) When specified, a Progressive All Ingot Nick and Break Test with Elimination of X-Rayls shall be performed as follows:

(*1*) A test specimen representing the top of the top rail from each ingot of each heat rolled, which has passed the requirements prescribed in Section 11, shall be nicked and broken to determine whether the interior metal is sound. If an interior defect shows on the fracture, the top end of the top rail shall be nicked and broken back. If a fracture free from interior defect is reached at a point permitting the rail to be finished to an acceptable length, the rail and the following rails of the ingot shall be accepted. If not, the rail shall be rejected and a test specimen cut from its bottom end to represent the second rail of the ingot. The second and third rails shall be tested in the same manner as the first rail. If the third rail is rejected, all the remaining rails of the ingot shall be rejected without further testing.

(*2*) The nick and break tests on the top end of the rails shall be made at increments at the option of the manufacturer and, if necessary, in order to obtain a fracture free from interior defects, the tests shall be carried to the point where the finished rail will be of minimum acceptable length.

(*3*) An interior defect shall be interpreted to mean seams, laminations, cavities, interposed foreign matter, or a distinctly bright or fine-grained structure made visible by the destruction tests.

(*4*) Short rails produced under this procedure shall be excluded from consideration in the limiting percentages of Section 17.

Section 15.—Omit this section on Brinell indentation.

Section 20 (a).—Change the last sentence in this paragraph to read as follows by the addition of the italicized words:

They shall be sawed square at the ends, a variation of not more than $^1/_{32}$ in. ($^3/_{64}$ *in. for 152-lb. rail*) being permitted, and burrs shall be entirely removed.

Section 20 (c).—Change to read as follows:

When any finished rail shows conditions as described in Section 13 at either end or at any drilled hole, it shall be cut back to sound metal, and accepted *as a No. 1 or No. 2 short rail, subject to the requirements of Sections 17 and 23. If cut back or broken, a fracture specimen shall be furnished the inspector to determine the interior condition.*

Section 21 (b).—Omit the reference to Section 20 (*c*).

New Section.—Add a new Section 27 to the specifications to read as follows:

27. *Control Cooling.*—When control cooling is specified it shall be in accordance with either of the processes recommended by the American Railway Engineering Association Committee on Rail (See Appendix I or Appendix II).

APPENDIX I

A.R.E.A. Tentative Specifications for Controlled Cooling of Rails—1937

Proceedings, Am. Railway Engineering Assn., Vol. 38, p. 644 (1937).

1. When rails have cooled in the regular way on the runways and hot beds to a temperature between 725 and 1000 F. they shall be charged into proper boxes or containers for controlled cooling.
2. The temperature of the rails at charging shall be determined by a reliable radiation pyrometer directed at the top of the rail head at least 12 in. from the end.
3. Any rails showing a temperature thus determined below 725 F.* shall not be charged.
4. The handling of the rails between the hot bed and the slow cooling enclosures shall be carefully done to minimize cold straightening.
5. The number of rails charged into any box or container shall be sufficient to insure an average rate of cooling to 300 F. in a time period of not less than 15 hr. after being charged.
6. The temperature of the rails in the cooling box or container shall be recorded at regular intervals by a thermocouple located at the midsection of the pile of rails.
7. The box or container may be unloaded at any time after the temperature at the midsection of the pile of rails has reached 300 F.
8. Controlled cooled rails shall be marked "CC."

*Editor's Note.—This figure has been changed to agree with Section 1. As originally printed it was 700 F. and later corrected in the A.R.E.A. Proceedings.

APPENDIX II

A.R.E.A. Recommended Practice for Control Cooling of Railroad Rails—1941

Am. Railway Engineering Assn., *Bulletin* No. 430, February, 1942, p. 617.

1. All rails shall be cooled in the regular way on hot beds or runways until the temperature is between 725 and 1000 F., then charged immediately into the containers.
2. The temperature of the rails before charging shall be determined with a reliable pyrometer at the top of the rail head at least 12 in. from the end.
3. The handling of rails between the hot bed and the container and their subsequent removal shall be carefully conducted to avoid bending and to minimize cold straightening.
4. The cover shall be placed on the container immediately after completion of the charge and shall remain in place for at least 10 hr. After the removal or raising of the lid of the container no rails shall be removed until the temperature of the top layer of rails has fallen to 300 F. or lower.
5. The temperature between an outside rail and the adjacent rail in the bottom tier of the container, at a point not less than 12, nor more than 36 in., from the rail end, shall be recorded with reliable equipment. This temperature shall be the control for judging rate of cooling.
6. The container shall be so protected or insulated that the control temperature shall not drop below 300 F. in 7 hr. from the time that the bottom tier is placed in the container.
7. All control-cooled rails shall be hot-stamped "CC," except that control-cooled rails which are also end hardened shall be hot-stamped "CH."

EA – A 25

Issued, June 22, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Wrought Steel Wheels for Electric Railway Service (A 25 – 41), and affects only the requirement referred to:

Section 4.—Change the present requirement for sulfur from "0.05 max., per cent" to read as follows:

Sulfur, max., per cent	basic steel	0.05
	acid steel	0.06

EA – A 57

Issued, June 22, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Multiple-Wear Wrought Steel Wheels (A 57 – 39) and affects only the requirement referred to:

Section 5.—Change the present requirement for sulfur from "0.05 max., per cent" to read as follows:

Sulfur, max , per cent	basic steel	0.05
	acid steel	0.06

EA – A 67

Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Steel Tie Plates (A 67 – 33) and affects only the requirements referred to:

Sections 3, 4, and 5.—Omit all requirements for copper and references thereto in these sections.

EA – A 160

Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Axle-Steel Bars for Concrete Reinforcement (A 160 – 39) and affect only the requirements referred to:

Section 2.—Change from its present form: namely,

2. The bars shall be rolled from carbon-steel axles for cars and locomotive tenders in the following standard journal sizes. No other axles or material shall be used:

	Standard Journal Sizes
Carbon-steel axles	$4\frac{1}{4}$ by 8 in.
	5 by 9 in.
	$5\frac{1}{2}$ by 10 in.
	6 by 11 in.

to read as follows:

2. In addition to axles, the bars may be rolled from new or used steel materials of sound character suitable for concrete reinforcement bars such as billets, bars, shafting, or structural shapes which do not qualify as to identity of melts under the Standard Specifications for Billet-Steel Bars for Concrete Reinforcement (A.S.T.M. Designation: A 15) of the American Society for Testing Materials. The manufacturer shall report to the purchaser the materials used in the manufacture of the bars.

Section 3 (a) and (b).—Omit these two paragraphs on carbon determination.

Section 7 (a).—Change from its present form: namely,

7. (*a*) One tension test and one bend test shall be made from each lot of ten tons or less of each size of bar rolled from each lot of axles assorted in groups as specified in Section 3.

to read as follows:

7. (*a*) One tension test and one bend test shall be made from each lot of ten tons or fraction thereof of each size of bar in a shipment rolled from each type of material.

EA – A 167

Issued, May 7, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Corrosion-Resisting Chromium-Nickel Steel Sheet, Strip, and Plate (A 167 – 41) and affect only the requirements referred to:

Table I.—Make the following changes in the requirements as to chemical composition:

Grade	Type Number	Element	Change Present Requirements From	To Read
5	321	Manganese, per cent	1.50 max.	2.00 max.
		Chromium, per cent	18.00 min.	17.00 to 19.00
		Nickel, per cent	8.00 min.	8.00 to 12.00
6	347	Manganese, per cent	1.50 max.	2.00 max.
		Chromium, per cent	18.00 min.	17.00 to 19.00
		Nickel, per cent	8.00 min.	8.00 to 12.00
		Columbium min., per cent	ten times the carbon content	eight times the carbon content
11	316	Carbon, per cent	0.08 max.	0.10 max.
		Chromium, per cent	16.00 min.	16.00 to 18.00
		Nickel, per cent	10.00 min.	10.00 to 14.00
12	317	Carbon, per cent	0.08 max.	0.10 max.
		Chromium, per cent	18.00 min.	17.50 to 20.00
		Nickel, per cent	10.00 min.	10.00 to 14.00

Change the requirements for phosphorus for all grades covered by these specifications from "0.035" to read "0.040" per cent, max.; also change the requirements for sulfur for all grades from "0.030" to read "0.040" per cent, max.

EA – A 177
Issued, May 7, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for High-Strength Corrosion-Resisting Chromium-Nickel Steel Sheet and Strip (A 177 – 39) and affect only the requirements referred to:

Section 4.—In the table of requirements as to chemical composition, change the requirement for phosphorus from "0.035" to read "0.040" per cent, max.; also change the requirement for sulfur from "0.035" to read "0.040" per cent, max.

EA – A 183
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Heat-Treated Carbon- and Alloy-Steel Track Bolts and Nuts (A 183 – 40 T) and affect only the requirements referred to:

Sections 1, 3 (a), 4 (a), 6 (a), and 8 (b).—Omit all requirements for alloy-steel and references to alloy-steel track bolts in these sections.

Section 14.—Add a new sentence preceding the last sentence to read as follows:

Other wrench-tight fits with a 50-lb. range in wrench tightness (with a 24-in. wrench) or hand-free fit, may be specified by the purchaser.

EA – A 186
Issued, June 22, 1942

The following Emergency Alternate, Provision when specified, may be used as an alternate in A.S.T.M. Standard Specifications for One-Wear and Two-Wear Wrought Steel Wheels (A 186 – 39) and affects only the requirement referred to:

Section 5.—Change the present requirement for sulfur from "0.05 max. per cent" to read as follows:

Sulfur, max., per cent	basic steel	0.05
	acid steel	0.06

EA – A 190
Issued, June 18, 1942

The following Emergency Alternate Provisions, when specified may be used as alternates in A.S.T.M. Standard Specifications for Lightweight and Thin-Sectioned Gray Iron Castings (A 190 – 40) and affect only the requirements referred to:

Section 1.—Change the last two sentences from their present form to read as follows:

Strength is not a primary consideration in the castings covered by these specifications, so all reference to classification by strength or to physical tests for strength is intentionally omitted. In those cases where some test is felt necessary to determine serviceability, such test should be made as provided in Section 3.

Omit the note which follows this section.

Section 3.—Change from its present form to read as follows:

3. *Physical Tests.*—On mutual agreement by the manufacturer and the purchaser, it is permissible to test castings in service and to test individual castings to destruction. The cost of such tests shall be borne by the purchaser. When such tests are mutually agreed upon, it is advisable that details thereof and provisions for acceptance and rejection be included in the order or purchase contract. Castings ordered to tensile strength or transverse strength requirements should be purchased in accordance with the Standard Specifications for Gray Iron Castings (A.S.T.M. Designation: A 48) of the American Society for Testing Materials.

Section 9.—Change from its present form to read as follows:

9. *Certification.*—Upon request of the purchaser, the manufacturer shall be prepared to certify that his product conforms to any physical test requirements or alloy analysis covered by these specifications.

EA – A 240
Issued, May 7, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Corrosion-Resisting Chromium-Nickel Steel Sheet, Strip, and Plate for Fusion-Welded Unfired Pressure Vessels (A 240 – 41) and affect only the requirements referred to:

Table I.—Make the following changes in the requirements as to chemical composition:

Grades S and M	Change the carbon content from "0.07" to read "0.08" per cent, max. Change the phosphorus content from "0.035" to read "0.040" per cent, max. Change the sulfur content from "0.03" to read "0.040" per cent, max.
Grade C	Change the carbon content from "0.07" to read "0.10" per cent, max. Change the columbium content from "not less than ten times the carbon content and not more than 1 per cent" to read "not less than eight times the carbon content and not more than 1 per cent." Change the phosphorus content from "0.035" to read "0.040" per cent, max. Change the sulfur content from "0.03" to read "0.040" per cent, max.
Grade T	Change the carbon content from "0.07" to read "0.10" per cent, max. Change the titanium content from "not less than five times the carbon content and not more than 0.60 per cent" to read "not less than four times the carbon content and not more than 0.60 per cent." Change the phosphorus content from "0.035" to read "0.040" per cent, max. Change the sulfur content from "0.03" to read "0.040" per cent, max.

EA – A 241
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Hot-Worked High-Carbon Steel Tie Plates (A 241 – 41) and affects only the requirements referred to:

Section 4.—Omit all references to copper in Paragraphs (*a*) and (*b*) of this section.

EA – A 244
Issued, June 22, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Heat-Treated Wrought Steel Wheels (A 244 – 41 T) and affects only the requirement referred to:

Section 6.—Change the present requirement for sulfur for all three classes A, B, and C from "0.05 max., per cent" to read as follows:

Sulfur, max., per cent	basic steel	0.05
	acid steel	0.06

EA – B 30
Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 41 T) and affect only the requirements referred to:

Table II.—Add the chemical composition requirements for alternate alloys 2X, 2Y, 2Z, 3X, 3Y, 3Z, 3W, 5X, 6X, and 6Y, as prescribed in the accompanying Table I.

TABLE I.—CHEMICAL COMPOSITION REQUIREMENTS. (EA – B 30)

Classification	Tin Bronze			High-Leaded Tin Bronze				Leaded Red Brass and Leaded Semi Red Brass	Leaded Yellow Brass	
Numerical Designation of Alternate Compositions	2X	2Y	2Z	3X	3Y	3Z	3W	5X	6X	6Y
Copper, per cent	86.00 to 89.00	86.00 to 89.00	85.00 to 88.00	77.00 to 81.00	82.00 to 85.00	75.00 to 79.00	67.00 to 71.00	78.00 to 82.00	66.00 to 74.00	66.00 to 74.00
Tin, per cent	7.50 to 9.00	7.50 to 11.00	7.50 to 9.00	6.00 to 7.50	7.00 to 9.00	5.50 to 7.00	4.00 to 5.50	2.50 to 3.25	0 to 1.50[a]	0 to 1.50[a]
Lead, per cent	0.90 max.	0.50 max.	1.00 to 2.25	8.00 to 11.00	7.00 to 9.00	13.00 to 16.00	23.00 to 27.00	6.00 to 8.00	2.00 to 4.00	2.00 to 4.00
Zinc, per cent	3.00 to 5.00	1.00 to 5.00	3.00 to 5.00	2.00 to 4.00	0.75 max.	1.25	0.75	7.00 to 10.00	remainder	remainder
Nickel, max., per cent	1.00	1.00	1.00	0.50	1.00	0.75	1.00	1.00	1.00[a]	1.00[a]
Iron, max., per cent	0.20	0.20	0.25	0.15	0.15	0.15	0.15	0.40	0.60	0.60
Antimony	....	....	....	0.75	....	0.75	0.75	....	....	....
Aluminum, per cent	none[b]	none[b]	none[b]	none[b]	none[b]	none[b]	none[b]	none[b]	none[b]	0.20 to 0.50
Silicon, max., per cent	0.005	0.005	0.005	0.003	0.003	0.003	0.003	0.003	....	....
Phosphorus, per cent	0.05 max.	0.02 max.	0.05 max.	0.05 max.	0.20 to 0.50	0.08 max.	0.05 max.	0.02 max.	....	....
Total other constituents,[c] max., per cent	0.35	....	0.35	0.35	0.50	0.35	0.35	0.50	0.35	0.35

[a] Tin and nickel shall not be intentionally added.
[b] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.
[c] Analysis shall regularly be made only for the elements specifically mentioned in Table II. If the presence of other elements is suspected, or indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements is not in excess of the limits specified.

EXPLANATORY NOTE

NOTE.—In connection with these emergency alternate copper-alloy ingots, attention is called to the alternate brass and bronze castings covered in the following emergency alternate provisions in A.S.T.M. specifications for copper-alloy castings:

Designation	Emergency Alternate Provisions in	Emergency Alternate Alloys
EA - B 60	Standard Specifications for Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent (B 60 – 41)	2X, 2Y, 2Z
EA – B 62	Standard Specifications for Composition Brass or Ounce Metal Castings (B 62 – 41)	5X
EA – B 143	Tentative Specifications for Tin-Bronze and Leaded Tin-Bronze Sand Castings (B 143 – 41 T)	2X, 2Y, 2Z
EA – B 144	Tentative Specifications for High-Leaded Tin-Bronze Sand Castings (B 144 – 41 T)	3X, 3Y, 3Z, 3W
EA – B 145	Tentative Specifications for Leaded Red Brass and Leaded Semi Red Brass Sand Castings (B 145 – 41 T)	5X
EA – B 146	Tentative Specifications for Leaded Yellow Brass Castings for General Purposes (B 146 – 41 T)	6X, 6Y

EA – B 60

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Castings of the Alloy: Copper 88 Per Cent, Tin 8 Per Cent, Zinc 4 Per Cent (B 60 – 41), and affect only the requirements referred to:

Sections 1, 4, and 6.—In the case of castings for bearings and structural parts, alloys 2X, 2Y, and 2Z conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as substitutes for the 88-8-4 alloy.

In the case of castings for pressure parts, the Standard Specifications for Steam or Valve Bronze Castings (A.S.T.M. Designation: B 61) or alloy 2A conforming to the Tentative Specifications for Tin-Bronze and Leaded Tin-Bronze Sand Castings (A.S.T.M. Designation: B 143) of the American Society for Testing Materials may be used as a substitute for the 88-8-4 alloy.

TABLE I.—CHEMICAL AND TENSILE REQUIREMENTS

	Alloy 2X[a]	Alloy 2Y[b]	Alloy 2Z[c]
Nominal Composition	87-8-1-4	88-8-0-4	86½-8-1½-4
Chemical Requirements:			
Copper, per cent	86.00 to 89.00	86.00 to 89.00	85.00 to 88.00
Tin, per cent	7.50 to 9.00	7.50 to 11.00	7.50 to 9.00
Lead, per cent	1.00 max.	0.60 max.	1.00 to 2.50
Zinc, per cent	3.00 to 5.00	1.00 to 5.00	3.00 to 5.00
Nickel, max., per cent	1.00	1.00	1.00
Iron, max., per cent	0.25	0.25	0.25
Aluminum, per cent	none[d]	none[d]	none[d]
Silicon, max., per cent	0.005	0.005	0.005
Phosphorus, max., per cent	0.05	0.02	0.05
Total other constituents, max., per cent	0.35	...	0.35
Tensile Requirements:			
Tensile strength, min., psi	36 000	40 000	36 000
Yield strength[e] min., psi	16 000	18 000	16 000
Elongation in 2 in., min., per cent	18	20	15

[a] Alloy 2X is suitable for large bearings and structural parts.
[b] Alloy 2Y is suitable particularly for small bearings and bushings such as used in internal combustion engines and in torpedo tubes for the U. S. Navy.
[c] Alloy 2Z is suitable for bearings and structural parts.
[d] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.
[e] Yield strength shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

EA – B 62

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Composition Brass or Ounce Metal Castings (B 62 – 41), and affect only the requirements referred to:

Sections 4 and 6.—Alloy 5X conforming to the following requirements as to chemical composition and tensile properties may be used as a substitute for the 85–5–5–5 alloy:

	Alloy 5X (81-3-7-9)
Chemical Requirements:	
Copper, per cent	78.00 to 82.00
Tin, per cent	2.50 to 3.25
Lead, per cent	6.00 to 8.00
Zinc, per cent	7.00 to 10.00
Nickel, max., per cent	1.00
Iron, max., per cent	0.40
Aluminum, per cent	none[a]
Silicon, max., per cent	0.003
Phosphorus, max., per cent	0.02
Total other constituents, max., per cent	0.50

[a] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.

Tensile Requirements:	
Tensile strength, min., psi	29 000
Yield strength[b], min., psi	13 000
Elongation in 2 in., min., per cent	18

[b] Yield strength shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

EA – B 143

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Tin-Bronze and Leaded Tin-Bronze Sand Castings (B 143 – 41 T) and affect only the requirements referred to:

Tables II and III.—Alloy 2A may be used as a substitute for alloys 1A and 1B, in the case of castings for pressure parts.

In the case of castings for pressure parts, the Standard Specifications for Steam for Valve Bronze Castings (A.S.T.M. Designation: B 61) of the American Society for Testing Materials may be used as a substitute for alloys for 1A and 1B.

Alloys 2X and 2Y conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as substitutes for alloys 1A and 1B in the case of castings for bearings and structural parts.

Alloy 2X may be used as a substitute for alloy 2B.

Alloy 2Z conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as a substitute for alloy 1B, in the case of castings for bearings and structural parts.

TABLE I.—CHEMICAL AND TENSILE REQUIREMENTS. (EA – B 143)

	Alloy 2X[a]	Alloy 2Y[b]	Alloy 2Z[c]
Nominal Composition	87-8-1-4	88-8-0-4	86½-8-1½-4
Chemical Requirements:			
Copper, per cent	86.00 to 89.00	86.00 to 89.00	85.00 to 88.00
Tin, per cent	7.50 to 9.00	7.50 to 11.00	7.50 to 9.00
Lead, per cent	1.00 max.	0.60 max.	1.00 to 2.50
Zinc, per cent	3.00 to 5.00	1.00 to 5.00	3.00 to 5.00
Nickel, max., per cent	1.00	1.00	1.00
Iron, max., per cent	0.25	0.25	0.25
Aluminum, per cent	none[d]	none[d]	none[d]
Silicon, max., per cent	0.005	0.005	0.005
Phosphorus, max., per cent	0.05	0.02	0.05
Total other constituents, max., per cent	0.35	...	0.35
Tensile Requirements:			
Tensile strength, min., psi	36 000	40 000	36 000
Yield strength,[e] min., psi	16 000	18 000	16 000
Elongation in 2 in., min., per cent	18	20	15

[a] Alloy 2X is suitable for large bearings and structural parts.
[b] Alloy 2Y is suitable particularly for small bearings and bushings such as used in internal combustion engines and in torpedo tubes for the U. S. Navy.
[c] Alloy 2Z is suitable for bearings and structural parts.
[d] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.
[e] Yield strength shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

EA – B 144

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for High-Leaded Tin-Bronze Sand Castings (B 144 – 41 T) and affect only the requirements referred to:

Tables II and III.—Alloy 3B is recommended as an alternate or substitute for Alloy 3A.

Alloys 3X and 3Y conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as a substitute for alloy 3A.

Alloy 3Z conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as a substitute for alloy 3D.

Alloy 3W conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as a substitute for alloy 3E.

EA – B 145

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Leaded Red Brass and Leaded Semi Red Brass Sand Castings (B 145 – 41 T) and affect only the requirements referred to:

Tables I, II, and III.—Alloy 5X conforming to the following requirements as to chemical composition and tensile properties may be used as a substitute for alloys 4A, 4B, and 5A:

	Alloy 5X (81-3-7-9)
Chemical Requirements:	
Copper, per cent	78.00 to 82.00
Tin, per cent	2.50 to 3.25
Lead, per cent	6.00 to 8.00
Zinc, per cent	7.00 to 10.00
Nickel, max., per cent	1.00
Iron, max., per cent	0.40
Aluminum, per cent	none[a]
Silicon, max., per cent	0.003
Phosphorus, max., per cent	0.02
Total other constituents, max., per cent	0.50
Tensile Requirements:	
Tensile strength, min., psi	29 000
Yield strength,[b] min., psi	13 000
Elongation in 2 in., min., per cent	18

[a] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.

[b] Yield strength shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

EA – B 146

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Leaded Yellow Brass Sand Castings for General Purposes (B 146 – 41 T) and affect only the requiremetns referred to:

Tables I, II, and III.—In the case of castings for pressure parts, alloy 6X conforming to the requirements as to chemical composition and tensile properties prescribed in the accompanying Table I may be used as a substitute for alloys 6A, 6B, and 6C; and in the case of castings for bearings and structural parts, alloy 6Y may be used as a substitute for alloys 6A, 6B, and 6C.

TABLE I.—CHEMICAL AND TENSILE REQUIREMENTS. (EA – B 144)

	Alloy 3X	Alloy 3Y	Alloy 3Z	Alloy 3W
Nominal Composition	80-7-10-3	84-8-8-0	78-6-15-1	70-5-25-0
Chemical Requirements:				
Copper, per cent	77.00 to 81.00	82.00 to 85.00	75.00 to 79.00	67.00 to 71.00
Tin, per cent	6.00 to 7.50	7.00 to 9.00	5.50 to 7.00	4.00 to 5.50
Lead, per cent	8.00 to 11.00	7.00 to 9.00	13.00 to 16.00	23.00 to 27.00
Zinc, per cent	2.00 to 4.00	0.75 max.	1.25 max.	0.75 max.
Nickel, max., per cent	0.50	1.00	0.75	1.00
Iron, max., per cent	0.20	0.15	0.15	0.15
Antimony, max., per cent	0.75	....	0.75	0.75
Aluminum, per cent	none[a]	none[a]	none[a]	none[a]
Silicon, max., per cent	0.003	0.003	0.003	0.003
Phosphorus, per cent	0.05 max.	0.20 to 0.50	0.08 max.	0.05 max.
Total other constituents, max., per cent	0.35	0.50	0.35	0.35
Tensile Requirements:				
Tensile strength, min., psi	25 000	25 000	25 000	21 000
Yield strength,[b] min., psi	12 000	12 000	14 000	11 000
Elongation in 2 in., min., per cent	8	8	10	7

[a] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.
[b] Yield strength shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

TABLE I.—CHEMICAL AND TENSILE REQUIREMENTS. (EA - B 146)

	Alloy 6X[a]	Alloy 6Y[b]
Nominal Composition	70-1-3-26	70-1-3-26
Chemical Requirements:		
Copper, per cent	66.00 to 74.00	66.00 to 74.00
Tin, per cent	0 to 1.50[c]	0 to 1.50[c]
Lead, per cent	2.00 to 4.00	2.00 to 4.00
Zinc, per cent	remainder	remainder
Nickel, max., per cent	1.00[c]	1.00[c]
Iron, max., per cent	0.60	0.60
Aluminum, per cent	none[d]	0.20 to 0.50
Total other constituents, max., per cent	0.35	0.35
Tensile Requirements:		
Tensile strength, min., psi	30 000	30 000
Yield strength,[e] min., psi	11 000	11 000
Elongation in 2 in., min., per cent	20	20

[a] Alloy 6X is suitable for castings for pressure parts.
[b] Alloy 6Y is suitable for castings for bearings and structural parts.
[c] Tin and nickel shall not be intentionally added.
[d] The term "none" as applied to aluminum allowance is defined as 0.005 per cent when determined on a 10-g. sample.
[e] Yield strength shall be determined as the stress producing an elongation under load of 0.05 per cent, that is, 0.01 in. in a gage length of 2 in.

EA – B 148

Issued, May 26, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Aluminum-Bronze Sand Castings (B 148 – 41 T) and affect only the requirements referred to:

Table III.—Change the yield strength values for alloys 9A-1 and 9A-2 from their present form: namely,

	Alloy 9A-1 (As Cast)	Alloy 9A-2 (As Cast)
Yield strength, min., psi	28 000	35 000

to read as follows:

Yield strength, min., psi	26 000	33 000

EA – B 158

Issued, November 28, 1941

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Rope-Lay-Stranded and Bunch-Stranded Copper Cables for Electrical Conductors (B 158 – 41 T) and affects only the requirement referred to:

Section 5.—Delete the requirements in reference to the length of lay for bunch-stranded conductors in Section 5 (*d*) and substitute the following provisions:

In bunch-stranded conductors classes J, K, L, M, N, O, P, and Q of No. 18 A.w.g size, a maximum lay of 1 in. for the wires is permitted.

EA – D 224

Issued, May 11, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Asphalt Roofing Surfaced with Powdered Talc or Mica (D 224 – 41 T) and affects only the requirements referred to:

Section 11 (*a*).—Omit the requirements for protective coating on Nails prescribed in item (*2*) of this section.

EA – D 249

Issued, May 11, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Asphalt Roofing Surfaced with Coarse Mineral Granules (D 249 – 41 T) and affects only the requirements referred to:

Section 9 (*a*).—Omit the requirements for protective coating on Nails prescribed in item (*2*) of this section.

EA – D 375

Issued, June 18, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (D 375 – 42) and affect only the requirements referred to:

Section 5.—Omit the requirements for magnetic rating for both the ferrous and non-ferrous varieties of roving.

Section 17.—Omit this section which covers the procedure for determining the magnetic rating.

EA – D 496

Issued, May 15, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Chip Soap (D 496 – 39) and affect only the requirements referred to:

Section 3.—In the table of chemical composition requirements, add the following requirement for rosin:

Rosin acids, max., per cent based on finished product	20

Omit the requirement for titer which reads as follows:

Titer of the mixed fatty acids prepared from the soap, min.	39 C.

EA – D 498

Issued, May 15, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Powdered Soap (Nonalkaline Soap Powder) (D 498 – 39) and affect only the requirements referred to:

Section 3.—In the table of chemical composition requirements, add the following requirement for rosin:

Rosin acids, max., per cent based on finished product	20

Omit the requirement for titer which reads as follows:

Titer of the mixed fatty acids prepared from the soap, min.	39 C.

Computer for Picture Exposures

RECENTLY PUBLISHED by the American Standards Association is a photographic exposure computer as developed by an Emergency Technical Committee consisting of leading authorities in the photographic field, including representatives of various combat services. A request from the U. S. Navy had been made that a simple computer be developed which would cover a wide range of light and scenic conditions. A computer which can be purchased by interested civilians is exactly the same as that furnished the Army and Navy except for the cover and text stock. The photographer in using the computer concerns himself with three values: light index, scene index and film exposure index—details of the first two items being given in the computer. For use in conjunction with the tables, the computer includes a movable dial calculator. In actual operation, the Light Index (A) is added to the Scene Index (B). The sum of these values is set on the calculator dial opposite the Film Exposure Index (C). The proper lens opening and exposure time are then read directly from the dial.

Supplementing the tables which are designed to give the photographer satisfactory results under normal conditions is an appendix with suggestions on procedures to follow for abnormal conditions. Copies of the civilian edition can be obtained from the American Standards Association, 29 West 39th St., New York, N. Y., at $1 per copy.

Important Standardization Projects Being Developed

Standing Committees Have Many New Specifications and Testing Procedures Under Way Including Numerous Emergency Recommendations

MANY OF THE STANDING committees of the Society have important standardization projects under way, some of which are referred to in the preprinted committee reports presented at the 1942 annual meeting; others were discussed at the Atlantic City meeting or are referred to in recent communications from the officers. It is hoped that a number of these activities can be completed in time for action by Committee E-10 on Standards late in August so that they can be incorporated in the 1942 Book of Standards. The following paragraphs mention various standardization projects and will give some advance information to the members on matters in which many are interested.

Ferrous Metals

Steel.—There are two fields where Committee A-1 on Steel will be asked to take some action, both involving the National Emergency Steel Specifications work: first, pertaining to numerous emergency provisions in pipe and tubing specifications, quite a number of which are now being balloted on in Subcommittee IX on Steel Tubing and Pipe. These will be referred to the Society in the near future. The other matter involves another Technical Advisory Committee on Heavy Forgings which may ask A.S.T.M. to issue several emergency specifications covering large forgings for use in turbines, shipshafting, heavy engines, and related applications where no recognized standard specifications are now available. Several meetings of the TAC have been held and specifications drafted.

Another matter involves specification requirements for converter cast steel for which a special section of Committee A-1 has been appointed.

Cast Iron; Malleable-Iron Castings.—In addition to the Tentative Method of Compression of Cast Iron approved at the annual meeting on the recommendation of Committee A-3, a new recommended practice on torsion testing has been under development and may be offered to the Society in the near future.

An important problem before Committee A-7 on Malleable-Iron Castings involves specifications covering physical properties for pearlitic malleable of various grades.

Magnetic Properties.—Committee A-6 on Magnetic Properties had an active year and there are three tests, published in its report, which will be referred to the Society in August for approval covering: permeability of feebly magnetic materials; measurement of permeability and core loss of flat-rolled magnetic materials; and determination of the incremental permeability and core loss of magnetic materials at low alternating inductions.

The committee also plans a critical review of the nomenclature and standard definitions of terms used in magnetic testing.

Chemical Analysis of Metals.—Committee E-3 is completing new methods for analysis of solder which will replace existing methods E 18, and also has proposed methods for analysis of zinc-base die castings. Later in the year it is possible that procedures for determining selenium in steel will be complete and an important standard covering apparatus and reagents is also in prospect.

Non-Ferrous Metals and Alloys

Copper Alloy Wire.—The matter of dimensional tolerances in specifications under the jurisdiction of Committee B-1 on Copper and Copper-Alloy Wires for Electrical Conductors will be studied to see if they are in accord with current practice. Also to be looked into are other stranding constructions than those covered in the three new tentative specifications announced in this BULLETIN. The lay of wires used in the specifications for bunched strands must be determined and correlated with Underwriters' Specifications, etc. The Emergency Specifications ES–1 which cover lead-coated and lead-alloy-coated copper wire for electrical purposes are involved in studies of tests for weight of coating; a hot-dip method and an electrodeposited method of applying coatings will be investigated.

"Electrical" Alloys.—In Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys the magnetic permeability test is being investigated as a criterion primarily of creep strength at high temperature. The group in charge also had published in the annual report Proposed Specifications for Chromium-Nickel-Iron Alloy Castings for High-Temperature Service. One of the most active phases of work involves contact materials in which a new life test machine is in use at a number of laboratories and calibration tests and cooperative test work is under way. Another project involves the preparation of a list of standard sizes of solid contact rivets which have been made in a great variety of sizes.

Copper and Copper Alloys.—Continued activity in the field of copper and copper alloys through Committee B-5 is indicated with the preparation of new specifications for copper bus bars in various commercially available forms now nearing completion. The existing Specifications B 120 (Beryllium Copper) are to be divided into two specifications, one to cover rod and wire, the other, sheet and strip. Standard requirements for rods for use as valve stems is another item on the B-5 docket.

As an emergency matter a new specification for silicon bronze castings is being completed which it is hoped can soon be issued as an A.S.T.M. emergency standard.

Electroplating.—Extensive work is under way in Committee B-8 on Electrodeposited Metallic Coatings involving plating and allied procedures which are related to the war effort. Emergency specifications covering preparation of cold-rolled steel for electroplating and for electrodeposition of heavy chromium coatings are being drafted. An emergency specification which will cover corrosion resistance of electrodeposited lead and lead alloy coatings is under consideration.

"C" Committee Group—Lime, Refractories, Concrete

Clay Pipe.—An important problem confronting Committee C-4 on Clay Pipe involves the possible coordination of the A.S.T.M. Specifications for Clay Sewer Pipe (C 13 – 40) with new Federal Specifications SS-P-361a, which includes standards for extra strength clay pipe and somewhat different testing procedures as well as tolerances. Although no immediate recommendations were made as a result of lengthy discussion at the committee's meeting, a working subcommittee is to study the matter and report in the near future.

Lime.—Among the standardization activities carried on in Committee C-7 on Lime are the development of proposed specification requirements to cover hydrated lime for structural purposes, one item covers lime for mortar purposes and the other for finishing hydrated lime. A corollary of this work is the development of suitable steam pressure method of test.

At its Atlantic City meeting, the Committee on Lime discussed a possibility of drafting master specifications for chemical lime. To stimulate action, a draft of such specification will be compiled and considered at the next committee meeting.

Another matter involves determination of available lime and it is proposed that the rapid sugar test for determining available lime in high calcium chemical lime and hydrated lime, be proposed as a tentative revision of the existing chemical methods C – 25.

Refractories.—In the field of refractories where Committee C-8 has done such important work, a Recommended Practice for Panel Spalling Test has been prepared and sent to five laboratories to obtain suggestions which it is hoped may lead to publication as an A.S.T.M. document. One of the important pieces of work is that on heat transfer, in cooperation with the National Bureau of Standards. Based on unusually good reproducible results, a recommended test method will be presented at the meeting of the committee later in the year. It appears that both types of equipment used give good reproducibility in determining the conductivity of insulating fire brick.

A subcommittee on specifications is preparing requirements on cold water mortars which it is hoped can soon be completed.

Concrete and Aggregates.—One of the important contributions in this field will be the report of Committee C-9 referred to in another article in this Bulletin, covering significance of tests. The committee is also developing a proposed test for measuring accelerated bleeding or water gain of concrete. A new test for surface moisture in fine aggregates has been proposed and will be studied. Another project is the development of a formula, practical of application, for measuring the concordance of field tests of ready-mixed concrete and of determining compliance of such field tests with specification requirements.

Gypsum.—Committee C-11 on Gypsum will continue its studies of proposed tests covering the water permeability of gypsum sheathing board and also the subsieve fineness determination of gypsum particles. This latter is a long-time project with no recommendations anticipated during the year.

"D" Committees—Paints, Coal, Road Materials, Etc.

Paints, etc.—In recent years Committee D-1 on Paint, Varnish, Lacquer, and Related Products has had prominently in mind practical assistance to the engineer with respect to the application of paint to steel structures and the judgment of service results to be obtained from different coatings. The test of various classes of preparatory treatments is well toward completion. As soon as industrial conditions permit, additional series of tests of materials and methods of application will be started on the basis of plans now being developed.

Photographic standards are progressing to show ratings for such details of deterioration as chalking, checking, cracking, erosion, flaking, mildew, blistering, etc. These will also be applicable to coatings on wood.

Tentative emergency methods for determining the protective properties of organic coatings (1) when subjected to humidity, and (2) when subjected to water immersion, will soon be issued. The second of these will include a set of pictorial standards for blistering. These will shortly be followed by methods for testing resistance to condensation moisture and to alternate water immersion and atmospheric exposure.

A new subcommittee is developing test methods for traffic paints which should lead subsequently to purchase specifications.

Good progress is being made on methods for testing bituminous emulsions to be used for coatings. This work should be finished within the next few months. It is to be followed by material specifications for the emulsions.

The committee expects to devise tests and specifications to differentiate further the individuals in the series of paint and varnish solvents which are derived from petroleum. The standards would cover composition, solvent and other properties.

Petroleum.—Among the problems on which Committee D-2 on Petroleum Products and Lubricants will work during the coming year are the following: (1) An informal group will draft a method for determination of sulfur in butadiene which activity would be warranted in view of the present emergency; (2) four methods for determining sulfur, chlorine, and phosphorus in extreme pressure lubricants have been agreed upon and will be distributed to the committee members for comment; (3) the work involving oxidation in Technical Committee C on Fuel Oils includes research on four oils, two of which contain inhibitors. Following study of the results, a recommendation on the method to be used may be made.

Gaseous Fuels.—While the work on gaseous fuels is not in the stage for specification or standard test development, some of the most extensive and exhaustive research work ever undertaken under Society auspices has been under way for some time in Committee D-3. Reference to the work is made in the annual report of the committee which gives some concept of the extent of the cooperative tests.

Road Materials.—Proposed new specifications for crushed gravel for water-bound base and surface courses, and gravel for bituminous concrete base and surface courses have been completed by Committee D-4 and will be submitted to the Standards Committee of A.S.T.M. in August.

Coal and Coke.—For information and comment, Com-

mittee D-5 proposes to draft standards covering two volumetric methods for determination of sulfur in coal and coke. Based on an extensive statistical study reported at the annual meeting in a technical paper, present tolerances for duplicate determinations will be studied in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271). An important combination of two widely used standards—Method of Sampling Coal for Analysis (D 21) and Method of Sampling Coals Classed According to Ash Content (D 492)—may be effected during the year.

Subcommittee XV on Plasticity and Swelling plans to draft various methods for the determination of plastic, swelling, and expansion properties of coals when burned in fuel beds or carbonized in coke ovens. It is the intention that these methods be published as information so various laboratories can have standardized procedures for use in making check determinations on a series of standard coals.

Rubber Products.—A most important project nearing completion in Committee D-11 on Rubber Products involves emergency specifications for fire hose which will be set up as an alternate to the existing Specifications D 296. Also to be issued as an emergency specification are requirements covering heat-resisting rubber compound. It is hoped a new tentative test can be completed this year covering compressed asbestos packings.

Soap.—In the work on soaps and other detergents, specifications for liquid soap, scouring soaps, and powders, are receiving particular attention. Another important phase of this committee's work involves evaluation of detergency.

Textiles.—Among the numerous activities which are being carried on in Committee D-13 on Textile Materials are the following:

Cotton:

1. Measurement of length and strength of cotton fibers
2. Cotton yarns and threads—test for ball warps, determination of regain, twist in single yarns, and various tests for yarn number and strength determinations
3. Method of testing rayon tire cord
4. Specifications for ducks (in D 230); also means of eliminating jaw breaks in testing

Rayon:

1. Number of tests required for determining denier and twist of rayon filament yarns
2. Evenness standards for spun rayon yarns and tests for resiliency of rayon staple

Wool:

1. New method of estimating clean content of wool in wool in the grease (cooperation with the Wool Trade and Treasury Department)
2. Specifications and methods of test for fiber content, acid determination, and fastness to soap and weather of felt
3. Methods of testing mothproofing and flame roofing of pile floor coverings

Asbestos:

1. Evaluation of grades of asbestos textile on a time temperature basis
2. Methods for determining relative value from insulation standpoint

Bast and Leaf Fibers:

1. Test for flax and hemp products (also for jute twine, sisal, and manila products)
2. Classification of commercially important fabrics with detailed characteristics

Household and Garment Fabrics:

1. Studies on the serviceability of sheeting and dishtoweling

Glass:

1. Determination of yarn number
2. Abrasion test
3. Corrosion of copper by sizing
4. Contraction of yarn due to twist

Methods and Machines:

1. Accelerated aging
2. Identification of fibers
3. Resilience of fibers
4. Soiling of textiles
5. Effect of rate of loading on strength and elongation of cotton yarns
6. Specifications for yarn reels and drying ovens

Naval Stores.—Committee D-17 on Naval Stores is following with interest studies under way on the crystallization of rosin at the plant of one of the largest producers and following reports on this work the committee will study tests for crystallizing tendency of rosin.

Committee D-17 has reorganized some of its subcommittees and one of the new ones covers terpenes other than turpentine. A study will be made to determine what specifications and standard methods of testing are needed, either by producers or consumers, for terpene products other than turpentine. Among these may be mentioned the pinenes, dipentene, and pine oils. Further collaborative work will develop from the results of the preliminary study.

Plastics.—That Committee D-20 on Plastics has numerous important standardization activities under way will be apparent from the following résumé of the program received from the committee:

Strength Properties.—Proposed tentative methods have been drafted (1) for tension testing of film materials, (2) for compressive strength testing of plastics, and (3) for flexural strength testing of plastics. Additional active work is being done on high-speed and repeated impact strength, shear strength, modulus of elasticity, bearing strength, and on the design of standard molds as the need arises.

Hardness Properties.—Active work is proceeding on tests for scratch hardness, indentation hardness, simplification of the heat distortion test and wear resistance of plastic bearings. The subcommittee is also considering the machinability of plastics.

Thermal Properties.—Proposed methods are nearing completion on thermal expansion and flow temperature of thermosetting materials. These will probably be ready by the next meeting. In addition work is proceeding on a high-temperature flammability method and it is planned to start developing a method for determining cubical expansion.

Optical Properties.—Work is being continued on descriptive nomenclature in order to widen the scope and to include laminated materials. Also methods are being developed for determining clarity of materials having less than one per cent scattering since present methods are not designed for these.

Permanence Properties.—Proposed tentative methods almost ready for D-20 letter ballot are: (1) water vapor permeability of plastic sheet material; (2) permanent effect of heat on plastics; (3) accelerated service testing to cover interior conditions (normal and dry winter), temperate zone, and tropical conditions. Work is being done on accelerated and outdoor aging and on accelerated service testing at conditions not covered by the above.

Specifications.—This new subcommittee is now well organized and is very actively engaged in setting up specifications for both thermoplastic and thermosetting materials. Work is being done in collaboration with various Government agencies, particularly the Quartermaster Corps, Ordnance Department of the War Department, Navy Bureau of Aeronautics and the Procurement Division of the Treasury Department.

The subcommittee is now setting up a common system of classification of all plastics by cooperative agreement with committees of other organizations such as the Plastic Materials Manufacturers' Association, the Society of Plastics Industry, and various Government committees. In addition, it is working up a standard form for materials specifications.

Partial List of Emergency Alternate Federal Specifications

FROM THE VERY large list of Emergency Alternate Specifications received at A.S.T.M. Headquarters there has been selected many which it is believed would be of concern to a reasonable cross-section of the Society's membership and the titles of these are given below. Constantly these emergency specifications are being issued, some to supersede previously issued emergency documents—in all cases, of course, the object is to expedite procurement or to conserve strategic or critical materials. In this BULLETIN reference is made to the reorganization of the Specifications Branch of the Conservation Division, War Production Board, which has representatives on the Federal Specification Committees responsible for these standards. All of the Federal Committees are making intensive efforts to make the specifications as practicable as possible.

Partial List of Emergency Alternate Federal Specifications

Specification Number	Description
E-DD-C-503	Cloths, Wiping; Cotton, Mixed and White, Sterilized (for) Machinery
E-HH-C-561b	Cork; Compressed (Corkboard) (for Thermal Insulation)
E-HH-G-71	Gaskets; Asbestos-Copper, Corrugated
E-HH-G-76	Gaskets; Asbestos, Metallic-Cloth
E-HH-I-556	Insulation (Glass-Fiber); Semi-Rigid
E-HH-I-571	Insulation (Vegetable or Wood-Fiber); Blanket, Felt, and Loose-Fill
E-HH-I-578	Insulation, Vermiculite; Block and Pipe-Covering (Molded)
E-HH-M-61	Magnesia; Block, Cement, and Pipe-Covering (Molded)
E-HH-M-371	Mineral-Wool Impregnated; Blanket, Block, and Pipe-Covering (Molded) (for Low Temperatures)
E-HH-P-31	Packing; Asbestos, Metallic-Cloth, Sheet
E-HH-P-36	Packing; Asbestos, Rod, High-Pressure
E-HH-P-46	Packing; Asbestos, Sheet, Compressed
E-HH-P-166	Packing; Semimetallic
E-HH-P-381	Pipe-Covering; Cork, Molded
E-HH-P-386a	Pipe-Covering and Cement; Mineral or Rock Wool
E-HH-T-101a	Tape; Friction (superseding E-HH-T-101a, dated January 30, 1942)
E-HH-T-111a	Tape; Rubber, Insulating (superseding E-HH-T-111a, dated January 14, 1942)
E-J-C-121	Cable and Wire; Rubber-Insulated, (for) Other than Building Purposes, Superaging Grade (0 to 8000-Volt Service)
E-KK-L-261b	Leather; Sole (Cut-Outer, and Top-Lift), Vegetable-Tanned, Factory
E-P-D-221	Detergent, Hand; Paste and Powder (for) Mechanics' Use
E-P-D-236	Detergents, Special; (for Aluminumware, Dishwashing-Machines, and Manual Cleaning)
E-P-S-566a	Soap; Chip
E-P-S-571a	Soap; Grit, Cake
E-P-S-576	Soap; Grit, Hand
E-P-S-591a	Soap; Laundry, Ordinary, Bar
E-P-S-596a	Soap; Laundry, Powdered
E-P-S-598	Soap, Liquid and Paste; (for) Automobile, Floor, and General Cleaning
E-P-S-603	Soap, Potash-Linseed-Oil; Liquid and Paste, (for) Floor and General Cleaning
E-P-S 606a	Soap Powder
E-P-S-611a	Soap; Salt-Water
E-P-S-616a	Soap, Toilet; Floating, White
E-P-S-618a	Soap; Toilet, Liquid
E-P-S-621a	Soap, Toilet; Milled
E-P-S-628	Soap-Borax-Compound; Toilet, (for) Dispensers
E-QQ-A-601	Aluminum-Base-Alloys; Sand Castings (superseding E-QQ-A-601, dated October 15, 1941)
E-QQ-B-71a	Bars; Reinforcement, (for) Concrete
E-QQ-B-666	Bronze, Aluminum; Bars, Plates, Rods, Shapes, Sheets and Strips (superseding E-QQ-B-666, dated September 12, 1941)
E-QQ-B-671a	Bronze Aluminum; Castings (superseding E-QQ-B-671a, dated November 18, 1941)
E-QQ-B-746	Bronze, Phosphor; Bars, Plates, Rods, Shapes, Sheets, and Strips (superseding E-QQ-B-746, dated September 12, 1941)
E-QQ-C-501a	Copper; Bars, Plates, Rods, Shapes, Sheets, and Strips
E-QQ-C-591a	Copper-Silicon-Alloy; Bars, Plates, Rods, Shapes, Sheets, and Strips (superseding E-QQ-C-591a, dated November 28, 1941)
E-QQ-C-593	Copper-Silicon-Alloy; Castings (superseding E-QQ-C-593, dated November 28, 1941)
E-QQ-I-706a	Iron and Steel; Sheet, Tinned (Tin-Plate) (superseding E-QQ-I-706a, dated August 16, 1941)
E-QQ-N-321	Nickel-Silver (German-Silver); Bars, Plates, Rods, Shapes, Sheets, and Strips (superseding E-QQ-N-321, dated September 12, 1941)
E-QQ-T-191	Terne-Plate (Long Ternes) (superseding E-QQ-T-191, dated August 16, 1941)
E-QQ-T-201	Terne-Plate (Roofing Tin) (superseding E-QQ-T-201, dated September 12, 1941)
E-QQ-W-432	Wire, Steel; Market (superseding E-QQ-W-432, dated July 23, 1941)
E-QQ-W-446	Wire; Steel, Zinc-Coated (for Wire-Bound Boxes) (superseding E-QQ-W-446, dated June 20, 1941)
E-RR-C-96	Cans; Tinned-Plate, Friction-Covers (superseding E-RR-C-96, dated January 14, 1942)
E-RR-F-191	Fencing; Chain-Link or Welded (Including Gates, Posts, Wire, etc.) (superseding E-RR-F-191, dated March 19, 1942)
E-RR-F-221	Fencing; Wire (Barbed, Netting, and Woven), Black and Galvanized (superseding E-RR-F-221, dated December 9, 1941)
E-RR-R-571	Rope; Wire (superseding E-RR-R-571, dated March 9, 1942)
E-SS-C-191b	Cement; Portland
E-SS-C-201a	Cement; Portland, High-Early-Strength
E-SS-C-206a	Cement; Portland, Moderate-Heat-of-Hardening
E-TT-B-486	Blue-Lead; Basic-Sulfate, Dry and Paste-In-Oil
E-TT-E-496	Enamel; Heat-Resisting (400 Deg. Fahr.), Black
E-TT-E-506a	Enamel; Interior, Gloss, Light-Tints, and White
E-TT-E-521	Enamel; Pigmented (Air-Drying and Baking) Black
E-TT-O-356	Oil; Flatting
E-TT-P-20	Paint, Blue-Lead-Base; Basic-Sulfate, Linseed-Oil, Ready-Mixed
E-TT-P-27	Paint; Graphite, Outside, Ready-Mixed, Black (superseding E-TT-P-27, dated February 24, 1942)
E-TT-P-51a	Paints; Oil, Interior, Eggshell-Flat-Finish, Ready-Mixed and Semipaste, Light-Tints and White
E-TT-P-88	Paint; Resin-Emulsion, Interior, Paste, Light Tints, and White
E-TT-P-101a	Paint; Titanium-Zinc and Titanium-Zinc-Lead, Outside, Ready-Mixed, White (superseding E-TT-P-101a, dated February 24, 1942)
E-TT-P-641	Primer, Paint; Zinc Dust-Zinc Oxide (for Galvanized (Zinc-Coated) or Zinc Surfaces)
E-TT-P-691	Prussian-Blue; Dry, Paste-In-Japan, Paste-In-Oil
E-TT-R-191a	Red-Lead; Dry and Paste-In-Oil
E-TT-S-271	Shellac; Orange

E-TT-U-451a	Ultramarine-Blue; Dry, Paste-In-Japan, Paste-In-Oil (superseding E-TT-U-451a, dated April 25, 1942)
E-TT-V-61	Varnish; Damar
E-TT-V-91a	Varnish; Shellac
E-TT-W-251a	White-Lead; Basic-Carbonate, Dry, Paste-In-Oil and Semipaste Containing Volatile Thinner
E-TT-W-261a	White Lead; Basic-Sulfate, Dry and Paste-In-Oil
E-TT-W-546	Wood-Preservative; Celcure (Acid-Cuptic-Chromate)
E-TT-W-551	Wood-Preservative; Chromated-Zinc-Chloride
E-TT-W-571b	Wood-Preservative; Recommended Treating Practice (superseding E-TT-W-571b, dated January 22, 1942)
E-TT-W-573	Wood Preservative; Wolman Salt (Tanalith)
E-TT-Z-301	Zinc-Oxide; Dry and Paste-In-Oil
E-TT-Z-321	Zinc-Oxide; Leaded, Dry, and Paste-In-Oil
E-UU-T-591	Towels; Paper
E-UU-P-79a	Paper; Blueprint (Sensitized and Unsensitized)
E-UU-P-268a	Paper; Kraft, Wrapping (superseding E-UU-P-268a, dated February 16, 1942)
E-UU-T-101b	Tape, Gummed; Mending, Reinforcing, and Securing
E-UU-T-111	Tape; Paper, Gummed (Kraft) (superseding E-UU-T-111, dated January 28, 1942)
E-UU-T-591	Towels; Paper
E-V-M-81a	Mattresses; Cotton (Felted) (superseding E-V-M-81a, dated April 11, 1942)
E-W-P-131a	Panelboards; Equipped with Automatic Circuit-Breakers (superseding E-W-P-131a, dated February 27, 1942)
E-WW-C-571	Conduit; Steel, Rigid, Enameled
E-WW-C-581a	Conduit; Steel, Rigid, Zinc-Coated (superseding E-WW-C-581a, dated June 30, 1941)
E-WW-T-806a	Tubing; Electrical, Metallic (superseding E-WW-T-806a, dated June 30, 1941)
E-ZZ-S-311a	Sheeting; Rubber
E-ZZ-H-451a	Hose, Fire; Cotton, Rubber-Lined (superseding E-ZZ-H-451a, dated February 24, 1942)
E-ZZ-H-461a	Hose; Gas (Acetylene, Air, Hydrogen, and Oxygen)
E-ZZ-T-831b	Tubing; Rubber (superseding E-ZZ-T-831b, dated March 31, 1942)

Material Substitutions, Issue No. 4

THE FOURTH ISSUE of "Material Substitutions" by the Bureau of Industrial Conservation, of the War Production Board, groups the current supplies as (I) inadequate for immediate essential needs, (II) sufficient for immediate essential needs, or (III) adequate for all types of presently apparent demands including use as substitutes. The stocks of materials in Group III are frequently in excess of demand in one part of the country while a deficiency exists elsewhere. Some fifty materials have been included in the tables since the last issue.

The items of Group I are inadequate in amount because of the diminished foreign supply or the very large demands for the war industries. Civilian industry not essential to the war effort is practically deprived of these materials but can frequently continue production by the substitution of materials in Groups II or III unless war needs necessitate diversion of their manpower or facilities.

The items of Group II are in fair supply as related to the war demands, although, in some instances their availability for such needs is attributable to the restrictions placed on the consumption of the materials for less essential uses.

Few metals or chemicals appear in Group III. This group includes the mass products of the coal mines, oil fields, quarries, forests, and fields. Many of these materials have already been substituted for scarce metals. Resourcefulness in getting these items into replacement use for essential military and civilian needs may be an important factor in winning the war.

It should again be emphasized that the grouping of the materials represents the current situation. The relative scarcity of our materials is constantly changing as war needs increase and the substitution program progresses.

Group I.—The Available Supply of the Following Materials Is Inadequate for War and Essential Civilian Uses and in Many Cases for War Purposes Alone.

METALS

Alloy Iron
*Aluminum
Aluminum Pigments
*Brass
*Bronze
Cadmium
Chromium
Cobalt
*Copper
*Copper Scrap
Iridium
Lithium
*Magnesium
Manganese, Electro
Molybdenum
*Nickel and Nickel Alloys
*Nickel Scrap
Rhodium
*Tantalum
*Tin
*Tungsten
*Tungsten Carbide
*Vanadium
Wrought Iron
Zinc (high grade)

* Most critical.

Supply Status of Certain Steel Products

Very Critical	Critical
*Alloy and Shell Steel	Sheets and Strip
*Steel Plates	Wire Products
*Structural Steel and Steel Piling	Black and Terne Plate
*Seamless Steel Tubing, 4 in. and under	Rails and Reinforcing Steel
*Wire Rope	Semifinished Steel and Forgings
*Tinplate	Tool Steel Bars
	Pipe

CHEMICALS

Acetone
*Acryionitrile
Alcohol, Lauryl
Ammonia and Derivatives
Ammonium Cyanamide
Ammonium Sulfate
*Aniline and Derivatives
Anthraquinone Derivatives
Benzol and Derivatives
*Butadiene
Calcium Cyanamide and Derivatives
Cobalt Chemicals
Copper Chemicals
Cresols
Diphenylamine
Glycerol
Iron Oxide, Yellow
Hydrated
Mannitol
Naphthalene and Derivatives
Naphthenic Acids and Naphthenates
Pentarythritol
Phenol
Phosphates: Tricresyl
Triphenyl
Phthalic Anhydride and Derivatives
Silica Gel
Sodium Nitrate
Sorbitol
Sulfur Chlorides
*Toluol and Derivatives
Zinc Oxide (French)

MISCELLANEOUS PRODUCTS

Agar
Asbestos (long fiber)
Balsa Wood
Burlap
Cashew Nut Shell Oil
*Coconut Oil
*Copra
Corundum
Cotton: Chemical Pulp
Duck
Linters
Raw, Long Staple
Diamond Dies, fine sizes
Feathers (up to 4 in.), and Down (Goose and Duck)
Graphite (Madagascar Flake)
Hemp: Agave Fiber
Henequen
*Manila Fiber
Cordage
Seed
Sisal
Jewel Bearings
Jute
Kapok
Kyanite
Lumber: Better Grades Softwood ex. White Pines
Better Grades Hardwood ex. Gums
Methyl Methacrylate Sheets
Mica, Block
Nylon
Oiticica Oil
Palm Kernel Oil
Phenol Formaldehyde Resins and Plastics
Pig and Hog Bristles over 3 in.
Polystyrene
*Polyvinyl Chloride
Pyrethrum
Quartz Crystal
Quinine
Rapeseed Oil
Rayon, High Tenacit
Rotenone
Rubber: *Chlorinated
*Crude
*Latex
*Reclaimed
*Synthetic
Shearlings
*Shellacs
Silicon Carbide
Silk: *Raw
*Noils
*Garnetted Reclaimed
Sperm Oil
Teak
*Tung Oil

Group II.—Materials That Are Essential to the War Industries but the Supplies of Which Are Not as Limited as Those in Group I.

METALS

Aluminum Scrap
Aluminum, No. 12 remelt
Antimony
Bismuth
Calcium
Calcium-Silicon
Columbium
Ferrosilicon
Ferrotitanium

Iron: Gray Cast
Malleable
Mercury
Pig Iron and Scrap
Platinum
Ruthenium
Silicomanganese
Silicon and Alloys
Silver
Spiegeleisen
Steel: Bessemer
Chrome Stainless
"National Emergency"
Scrap
Zinc (low grades)
Uranium

CHEMICALS

Acetic Acid
Acetic Anhydride
Alcohol: Amyl
Ethyl
Methyl
Acrylic Acid and Acrylates
Alkyd Resins
Alumina
Aluminum Chemicals
Arsenic Trioxide
Atebrine (for Quinine)
Bleaching Powder
Bromine
Butanol
Butyl Acetates
Calcium Hypochlorite
Chlorates and Perchlorates
Chlorinated Hydrocarbon Solvents and Waxes
Chlorine
Chromium Chemicals
Citric Acid
Ethers
Formaldehyde
Glycol
Iodine
Isopropanol
Ketones, ex. Acetone
Lactic Acid and Lactates
Maleic Acid and Anhydride
Methyl Ethyl Ketone
Molybdenum Chemicals
Perchlorates
Phosphorus
Soda Ash
Strontium Salts
Xylol

MISCELLANEOUS PRODUCTS

Albumin, Blood
Alpha Cellulose (Wood Pulp)
Babassu Oil
Bauxite, Reduction Grade
Cadmium Pigments
Castor Oil
Cellophane
Cellulose Nitrate, Acetate, and Other Derivatives
Cohune Nuts and Kernels
Cork
Cotton Seed (SXP)
Cryolite
Diamonds, Industrial
Ester Gum
Flax
Fish Liver Oils
Fish Oils
Glues, Animal and Vegetable
Hair, Horse—Tail and Mane
Halogenated Hydrocarbon Refrigerants
Hides
Leather
Linseed Oil
Magnesite
Mercury Pigments
Methyl Methacrylate Powder
Mica, Splittings
Molasses
Natural Gas
Natural Resins, except Rosin
Neatsfoot Oil
Palm Oil
Paraffin
Pine Oil
Rayon Filament, Staple Fiber
Rutile
Steatite Talc
Tanning Materials
Tetraethyl Lead
Urea Formaldehyde Plastics
Vinyl Plastics and Resins
Vinylidine Chloride Plastic
Vitamin "A" Products
Vulcanized Fiber
Wool
Zircon

Group III.—Materials That Are Available in Significant Quantities as Substitutes for Less Available Materials, and Materials That Are Available in Large Amounts Unless Restrictions Are Imposed by Labor, Manufacturing, or Transportation Difficulties

METALS

Ferroboron
Ferromanganese
Gold
Indium
Lead
Osmium
Palladium
Sodium

CHEMICALS

Barium Carbonate
Borax and Boric Acid
Camphor
Caustic Soda
Chromic Acid for Plating
Muriatic Acid
Sodium Metasilicate

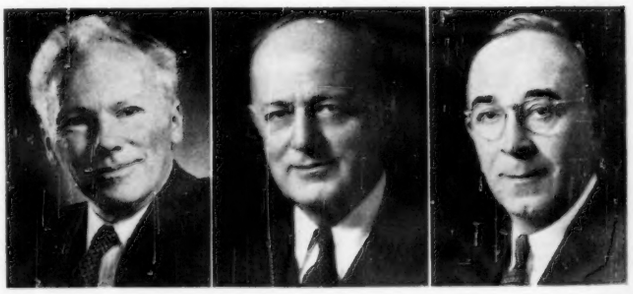
MISCELLANEOUS PRODUCTS

Asbestos, common
Asphalt
Bauxite, low grade
Bentonite
Brick and Tile
Carbon Black
Casein
Cement (Portland)
Ceramics
Charcoal
Clay
Coal and Coke
Coal Tar Pitch
Concrete, plain
Corn Stalks
Cotton, Raw, up to 1 3/8 in.
Cottonseed Oil
Diatomite
Emery
Feldspar
Felt, Hair
Fiber Board
Flint
Gilsonite
Glass
Gypsum and Products
Hair: Cattle, Calf and Goat
Invert Sugar
Lead Pigments
Lignin Extender for Plastics
Lime
Lithopone
Lumber and Millwork
Low Grades Soft and Hard Wood
All Grades Gums
All Grades White Pines
Mica, Ground
Mineral Wool
Paper (ex. Cellophane)
Paperboard
Peanut Oil
Petroleum Products
Crude Oil
Gasoline
Lubricating Oil
Plywood (unrestricted binder)
Pottery
Refractories (domestic)
Andalusite
Dumortierite
Kyanite
Rosin and Derivatives, except Ester Gum
Salt
Silica Sand
Soybeans, Oil, Protein
Spodumene
Starch, Domestic
Stone, Granite
Limestone
Marble
Slate
Soapstone
Straw
Sugar
Sulfur
Sunflower Seed Oil
Titanium Pigments
Tripoli
Turpentine
Vermiculite
Wallboard
Wood and Products
Sawdust
Wood Fiber
Wood Flour
Zinc Oxide (Am. Process

XXVII. Long-Time Society Committee Members

Twenty-seventh in the Series of Notes on Long-Time Members

As a continuation of the series of articles in the ASTM BULLETIN comprising notes on the outstanding activities of long-time A.S.T.M. members, there are presented below outlines of the work of three additional members. In general, the men whose activities are described in this series have been affiliated with the Society for 25 years or more and have taken part in committee work for long periods of time. No definite sequence is being followed in these articles.



A. V. de Forest J. G. Detwiler A. R. Ellis

A. R. ELLIS, President, Pittsburgh Testing Laboratory, Pittsburgh, Pa., graduated from Cornell University with the degree of C.E. in 1905. After this he became affiliated with the Pittsburgh Testing Laboratory, Milwaukee, Wis., and assisted in the installation and operation of its cement testing laboratory at West Allis, Wis. For several years he was located in Pittsburgh, Pa., inspecting at various mills of the Carnegie Steel Co., American Bridge Co., McClintic-Marshall Construction Co., and others. From 1908 to 1914 Mr. Ellis handled the entire field forces of PTL checking strain sheets, and carried on research work resulting in the development of the present-day high-pressure gas shipping container. He was located in New York City from 1914 to 1918 in connection with inspection services for European clients; from 1918 to 1921, he was Assistant to Chief Executive of PTL; 1921 to 1928, General Manager; and in 1928 he became Vice-President and Director of the Laboratory. He has been President and Director since 1936.

Mr. Ellis has been affiliated with the Society since 1915. He has served on Committees A-1 on Steel, C-1 on Cement, and C-9 on Concrete and Concrete Aggregates since 1924, and has been a member of Committee A-3 on Cast Iron since 1932. He is the new chairman of the Pittsburgh District Committee.

Mr. Ellis is a member of a number of other technical societies including the American Concrete Institute, American Society of Civil Engineers, Technical Advisory Board of American Institute of Steel Construction, Engineers Society of Western Pennsylvania, National Engineering Inspection Association, and American Welding Society. He is now serving as President of the American Council of Commercial Laboratories.

A. V. DE FOREST, Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass., received his technical training at M.I.T., graduating in 1911. He was with the New London Ship and Engine Co. after his graduation and was Instructor at Princeton University, 1913 to 1915. He was Assistant Research Engineer, Remington Arms U. M. C., 1916 to 1918; and Research Engineer, American Chain Co., 1918 to 1929. Following this he was Construction Engineer for a number of different companies including Spang Chalfant Co., John Chatillon and Co., and Hamilton Standard Propellers. He has invented various devices and methods for magnetic testing and inspection.

Doctor de Forest's membership in A.S.T.M. dates back to 1916. He was a member of Committee B-2 on Non-Ferrous Metals and Alloys from 1917 to 1922, and became a member of Committee A-8 on Magnetic Analysis in 1918, serving on this committee until it merged with A-6 on Magnetic Properties in 1936, and then continuing on A-6. He also served on Committee A-10 on Iron-Chromium-Nickel and Related Alloys.

Doctor de Forest is also affiliated with the American Society for Metals, American Institute of Mining and Metallurgical Engineers, American Association for the Advancement of Science, and Newcomen Society. He is a Fellow I.A.E., and Fellow, A.A.A.S. He has written technical papers for the A.S.T.M., A.S.M., Iron and Steel Institute, A.I.M.E., and International Association for Testing Materials and was awarded the Charles B. Dudley Medal by the A.S.T.M. in 1928 for his paper, "A Method of Graphic Representation of Magnetic Characteristics"; the Longstreth Medal of the Franklin Institute; the Sylvanus Albert Reed Award; I.A.S., and delivered the Howe Memorial Lecture in 1941 before the American Institute of Mining and Metallurgical Engineers.

J. G. DETWILER, Technologist, The Texas Company, New York, N. Y., received his education at The Pennsylvania State College, graduating in 1910 with a B.S. degree. During the year following his graduation he was connected with Lackawanna Steel Co., Jones and Laughlin Steel Co., and Dow Chemical Co., and in 1911, became affiliated with The Texas Company. He has been with this company for 31 years, except for two years, 1917–1919, in the U. S. Army.

Mr. Detwiler has been a member of A.S.T.M. since 1916, and has been active in a number of the Society's committees. He has served on Committee D-2 on Petroleum Products and Lubricants since 1922, and has, since its inception been secretary of Technical Committee B on Lubricants of Committee D-2. He is also a member of Committee D-1 on Paint, Varnish, Lacquer, and Related Products and Committee D-5 on Coal and Coke, and Sectional Committee G8 on Specifications for Zinc Coating of Iron and Steel. Mr. Detwiler also served for a number of years as a member of Committee D-9 on Electrical Insulating Materials, and is at present a member of the New York District Committee.

Another distinctive service which Mr. Detwiler rendered to the Society was as chairman of the committee in charge of the Symposium on Motor Lubricants held in 1933. This publication was very widely distributed and served as the basis for another Symposium on Lubricants held a few years later. Mr. Detwiler was secretary of the committee in charge of the second symposium.

Mr. Detwiler's other technical society affiliations include: American Chemical Society (chairman, Southwestern Texas Section, 1925; member executive committee, New York Section, 1931; Councilor, 1937); Society of Chemical Industry, American Petroleum Institute, and Franklin Institute.

Proposed Method of Verification and Classification of Strainometers[1]

Scope

1. This method covers procedures for the verification and classification of strainometers. (Note 1.) The method is applicable only to instruments that indicate or record values which are proportional to changes in length. Strainometers are classified on the basis of the magnitude of their errors. (Note 2.)

NOTE 1.—The term "strainometer" has been criticized because it is a word of hybrid derivation. The term "extensometer" has been suggested in its place, compression being regarded as negative extension. However, "extensometer" is not a suitable word to describe an instrument for measuring flexural deflection, shear strain, or twist. The terms "strain gage" and "deformeter" have also been suggested.

NOTE 2.—Strainometers should comply with the requirements for one of the classes prescribed in this method.

Definitions

2. (*a*) *Strainometer.*—A device for measuring strain, such as an extensometer, a compressometer, or a strain gage, of either the indicating or recording type.

(*b*) *Strain.*—The change per unit of length in a linear dimension of a body, which change accompanies a stress. Strain is measured in inches per inch (or millimeters per millimeter) of length.

(*c*) *Gage Length.*—The linear distance over which the change in length is measured.

NOTE.—For some strainometers the gage length is fixed by the positions of gage marks, while for others the gage length is adjustable and must be set for the desired gage length when the strainometer is attached to the specimen.

[1] This proposed method is under consideration by Committee E-1 on Methods of Testing through its Section on Calibration of Testing Machines and Apparatus. It was prepared by B. L. Wilson of the National Bureau of Standards.

TABLE I.—CALIBRATION DATA FOR A TYPICAL STRAINOMETER.

Calibration apparatus used Johansson Blocks with error not more than 0.000004 in., indicator sensitivity 0.000005 in.

Change in Length, in.	Strainometer Reading, Divisions			Change in Strain, in. per in.	Change in Strainometer Reading		
	Run No. 1	Run No. 2	Run No. 3		Run No. 1	Run No. 2	Run No. 3
0.00000	−0.09	−0.015	−0.055	0.00000	0.000	0.000	0.000
0.00100	0.245	0.32	0.275	0.00100	0.335	0.335	0.33
0.00200	0.57	0.65	0.60	0.00200	0.66	0.665	0.655
0.00300	0.895	0.97	0.92	0.00300	0.985	0.985	0.975
0.00400	1.22	1.295	1.25	0.00400	1.31	1.31	1.305
0.00500	1.555	1.625	1.58	0.00500	1.645	1.64	1.635
0.00500	−0.08	−0.08	−0.095				
0.00600	0.265	0.26	0.25	0.00600	1.99	1.98	1.98
0.00700	0.60	0.595	0.585	0.00700	2.325	2.315	2.315
0.00800	0.92	0.915	0.905	0.00800	2.645	2.635	2.635
0.00900	1.25	1.24	1.23	0.00900	2.975	2.96	2.96
0.01000	1.58	1.565	1.555	0.01000	3.305	3.285	3.285
					Calibration factor = 0.003033		

NOTE.—Measured gage length = 1.000 in.

(*d*) *Calibration Factor.*—The factor by which the change in strainometer reading must be multiplied to obtain the equivalent strain.

NOTE.—For any strainometer the calibration factor is equal to the ratio of change in length to the product of the gage length and the change in the strainometer reading. For direct reading strainometers the calibration factor is unity.

(*e*) *Error.*—In the case of a strainometer, the value obtained by subtracting the correct value of the strain from the indicated value given by the strainometer.

(*f*) *Calibration Apparatus.*—A device for calibrating strainometers consists of a mechanism to which strainometers may be attached and a means for measuring accurately changes in length.

Calibration Apparatus

3. The apparatus for calibrating strainometers shall consist of a rigid frame, suitable coaxial spindles, or other fixtures to which the strainometer may be attached, a mechanism for moving one spindle or fixture axially with respect to the other, and a means for measuring accurately the change in length so produced.[2] The mechanism provided for moving one spindle relative to the other shall permit sensitive adjustments. The changes in length shall be measured by means of an interferometer, calibrated standard gage blocks and an indicator, or a micrometer screw. If standard gage blocks and an indicator, or a micrometer screw, are used, they shall be calibrated and their limits of accuracy and sensitivity stated. The errors of the calibration apparatus shall not exceed one-fifth of the permissible error of the strainometer.

[2] A complete description of an extensometer comparator with which the changes in length may be measured either by means of standard gage blocks and an indicator or by means of the interferometer method is given in a paper by A. H. Stang and L. R. Sweetman, "An Extensometer Comparator," *Journal of Research*, Nat. Bureau of Standards, Vol. 15, No. 3, September, 1935, p. 199 (*Research Paper RP822*).

A description of a strainometer calibrating device which makes use of a calibrated differential micrometer screw is given in a paper by R. L. Templin, "The Calibration of Extensometers," *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part II, p. 714 (1928).

Assembly of Calibration Apparatus

4. (*a*) *Position of Strainometer During Calibration.*—The position of the strainometer during calibration shall preferably be the same as the position of the strainometer when it is attached to a test specimen, in order to avoid errors due to lack of balance or deformation of the parts of the strainometer.

(*b*) *Method of Attaching Strainometer.*—The strainometer shall be supported during calibration in the same way it is supported when it is attached to a test specimen.

(*c*) *Temperature Control.*—The strainometer shall be placed near or mounted on the calibration apparatus a sufficient length of time before calibration so that the calibration device and the strainometer shall be at very nearly the same temperature. The temperature of the room should be kept as nearly constant as possible during the calibration.

Range of Calibration

5. Strainometers shall be calibrated throughout the full ranges of the instruments or the full range used in testing.

Number of Observations

6. (*a*) *Number of Readings.*—The reading of the strainometer shall be observed for at least ten different readings of the calibration apparatus. The difference between any two successive readings shall not exceed

TABLE II.—ERRORS OF STRAINOMETER READINGS.

Change in Strain, in. per in.	Indicated Strain			Error		
	Run No. 1	Run No. 2	Run No. 3	Run No. 1	Run No. 2	Run No. 3
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00100	0.00102	0.00102	0.00100	0.00002	0.00002	0.00000
0.00200	0.00200	0.00202	0.00199	0.00000	0.00002	−0.00001
0.00300	0.00299	0.00299	0.00296	−0.00001	−0.00001	−0.00004
0.00400	0.00397	0.00397	0.00396	−0.00003	−0.00003	−0.00004
0.00500	0.00499	0.00497	0.00496	−0.00001	−0.00003	−0.00004
0.00600	0.00604	0.00601	0.00601	0.00004	0.00001	0.00001
0.00700	0.00705	0.00702	0.00702	0.00005	0.00002	0.00002
0.00800	0.00802	0.00799	0.00799	0.00002	−0.00001	−0.00001
0.00900	0.00902	0.00898	0.00898	0.00002	−0.00002	−0.00002
0.01000	0.01002	0.00996	0.00996	0.00002	−0.00004	−0.00004

one-eighth of the difference between the minimum and maximum readings.

NOTE.—If the connection between the gage points attached to the specimen and the indicating device is made through geared wheels or micrometer screws, relatively large periodic errors may exist which might not be disclosed by this over-all calibration. For such strainometers it may be necessary to take additional readings within one turn of any geared wheel, micrometer screw, or the travel of one tooth of any meshing gear.

(*b*) *Number of Runs.*—Three complete sets of strainometer readings shall be taken for the same changes in length. The strainometer shall be removed from the calibration apparatus and then replaced between runs.

Calibration Factor

7. The calibration factor of the strainometer shall be determined graphically or algebraically from the strainometer readings and the ratios of the changes in length of the calibration apparatus to the gage length of the strainometer.

Errors

8. The error of the strainometer shall be calculated for each change in length of the calibration apparatus.

Classification

9. Strainometers shall be classified in accordance with the following requirements as to maximum error of indicated strain:

	Maximum Error of Indicated Strain
Class A	0.00001
Class B	0.00005
Class C	0.0001
Class D	0.0005
Class E	0.002

NOTE.—Class A and class B strainometers would ordinarily be used for determining values of the modulus of elasticity and for delicate measurements of permanent set or very slight deviations from Hooke's law. Class C, class D, and class E strainometers would ordinarily be used for determining values such as the yield strength. Definitions of the terms "modulus of elasticity," and "yield strength" are given in the Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6) of the American Society for Testing Materials.[3]

Report

10. The report shall include the following:

(*1*) Method of verification used,
(*2*) Serial numbers and names of the manufacturers of all apparatus used in verifying the strainometer,
(*3*) A statement indicating how, by whom, and when the calibration of the apparatus used in verifying the strainometer was made,
(*4*) A statement of the errors of the calibration apparatus,
(*5*) Serial number and name of the manufacturer of the strainometer verified,
(*6*) Gage length of the strainometer,
(*7*) Position of the strainometer during calibration,
(*8*) Method of attaching the strainometer to the calibration apparatus,
(*9*) Complete tabulation of the readings of the strainometer and of the calibration apparatus,
(*10*) Calibration factor determined from the results of the verification,
(*11*) Error of the strainometer for each strainometer reading, and
(*12*) Class of the strainometer.

[3] 1939 Book of A.S.T.M. Standards, Parts I, II, and III.

APPENDIX

To illustrate the procedure for the verification and classification of strainometers described in this method, the results, obtained with a typical strainometer, are given. The data obtained during the calibration are given in the first four columns of Table I. The results calculated from these data are given in columns 5 to 8, inclusive, of Table I, and have been plotted in Fig. 1.

The indicated strains, obtained by multiplying each change in strainometer reading by the calibration factor, are shown in Table II. The error for each change in strainometer reading is also given in Table II and is plotted in Fig 2.

The calibration factor given in Table I was calculated from the results in columns 5 to 8, inclusive, of Table I by the method of least squares. In making the calculation, it was assumed that only the strainometer readings were subject to error. The calibration factor is proportional to the slope of the line drawn to represent the observed points in Fig. 1 and could, of course, have been determined from the graph.

Since the maximum error given in columns 5, 6, and 7 of Table II does not exceed 0.00005, the strainometer is classified as a class B strainometer.

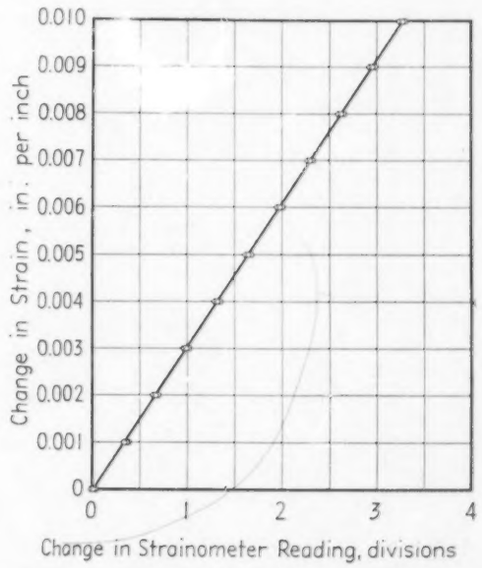


Fig. 1.—Relation of Changes in Strainometer Readings and in Strain.

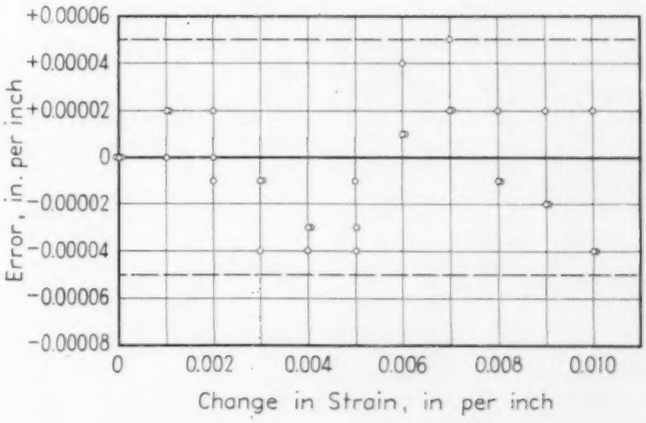


Fig. 2.—Error for Each Change in Strainometer Reading.

NEW MEMBERS TO JULY 15, 1942

The following 73 members were elected from May 2 to July 15, 1942:

Chicago District

ARMOUR RESEARCH FOUNDATION, Carl G. Anderson, Mechanical Engineer, 35 W. Thirty-third St., Chicago, Ill.

CRAWFORD, J. O., Research Engineer, Bell & Howell Co., 1801 Larchmont Ave., Chicago, Ill.

Cleveland District

PRESSURE CASTINGS, INC., Joseph Obermayer, Chief Engineer, 21500 St. Clair, Cleveland, Ohio.

YEARLEY, GEORGE, Chief Metallurgist, American Fork and Hoe Co., Geneva, Ohio.

Detroit District

KELSEY-HAYES WHEEL CO., John Sheppard, Chief Metallurgist, Plymouth, Mich.

NASH-KELVINATOR CORP., William Mikulas, Chief Metallurgist, 111 W. Mt. Hope Ave., Lansing, Mich.

WOODWORTH CO., N. A., R. R. Williams, Chief Metallurgist, 1415 Jarvis Ave., Ferndale, Mich.

DALZELL, R. C., Supervisor of Methods, Revere Copper and Brass Incorporated, Michigan Division, 5851 W. Jefferson Ave., Detroit, Mich.

FORD, MERLE, Professor and Head, Textiles, Clothing and Related Arts, Michigan State College, East Lansing, Mich.

HOENICKE, E. C., Sales Manager, Eaton Manufacturing Co., 9771 French Road, Detroit, Mich.

New York District

COOPER ALLOY FOUNDRY CO., THE, H. A. Cooper, President, Bloy St. and Ramsey Ave., Hillside, N. J.

INDUSTRIAL MINERAL WOOL INST., R. L. Davis, Secretary, 441 Lexington Ave., New York, N. Y.

NEPTUNE METER CO., Frank G. Hundley, Engineer, 192 Jackson Ave., Long Island City, N. Y.

PHILIPS METALIX CORP., F. G. Firth, Research Engineer, 419 Fourth Ave., New York, N. Y.

WATERBURY CLOCK CO., J. R. Putnam, Mechanical Engineer, 31 Cherry Ave., Waterbury, Conn.

ARMSTRONG, DURWARD T., Physical Chemist, Grumman Aircraft Engineering Corp., Bethpage, L. I., N. Y. For mail: 10 Lewis Road, Northport, L. I., N. Y.

BROOKLYN TECHNICAL HIGH SCHOOL, 29 Fort Greene Place, Brooklyn, N. Y.

DEMMLER, ALBERT W., Metallurgical Engineer, Vanadium Corporation of America, 420 Lexington Avenue, New York, N. Y.

GOTTSCHLING, FRED. W., JR., Chief Draftsman, Simmonds Aerocessories, Inc., New York, N. Y. For mail: 268 Seventy-fifth St., Brooklyn, N. Y.

HASKINS, DONALD W., Assistant Design Engineer, Wallace & Tiernan Co., Inc., 11 Mill St., Belleville, N. J.

HAZEN, THOMAS, Physicist, Bakelite Corp., 230 Grove St., Bloomfield, N. J.

HUBER, CHARLES J., Vice-President, U. S. Testing Co., Inc., Hoboken, N. J.

KOENIG, WILLIAM W., Methods Engineer, Sperry Gyroscope Co., Manhattan Bridge Plaza, New York, N. Y. For mail: 45-21 Forty-first St., Sunnyside, L. I., N. Y. [J]*

MARROCCO, GUY D., Technical Director, Carman and Co., Inc., New York, N. Y. For mail: 224 Bay 7 St., Brooklyn, N. Y.

SCHMID, EMIL, General Manager and Chief Chemist, Sika, Inc., 35 Gregory Ave., Passaic, N. J.

Northern California District

WILLIAMS, HARRY A., Associate Professor of Civil Engineering, Civil Engineering Department, Stanford University, Stanford University, California.

* [J]—denotes Junior Member.

Philadelphia District

APGAR, H. V., Metallurgist, Ingersoll-Rand Co., Phillipsburg, N. J.

BECK, PAUL A., Metallurgist, Beryllium Corporation of Pennsylvania, Reading, Pa. For mail: 630 Euclid Ave., Temple, Pa.

WHALEN, A. FLOYD, Chief Chemist and Metallurgist, Harrisburg Steel Corp., Harrisburg, Pa. For mail: 610 N. Sixteenth St., Harrisburg, Pa.

YODER, LEONARD G., Manager, Product Promotion, Beryllium Corporation of Pennsylvania, Reading, Pa. For mail: 621 N. Temple Boulevard, Temple, Pa.

Pittsburgh District

DUQUESNE SMELTING CORP., J. F. Ednie, Chief Metallurgist, 50 Thirty-third St., Pittsburgh, Pa.

MENARD, DAVID F., Industrial Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa. For mail: Wheeling Stamping Co., Wheeling, W. Va.

SIMON, RICHARD W., Manager, Metallurgical Division, Pittsburgh District, Carnegie-Illinois Steel Corp., 764 Frick Building Annex, Pittsburgh, Pa.

Southern California District

VEGA AIRCRAFT CORP., W. C. Hurty, Chief Structures Engineer, Lockheed Air Terminal, Burbank, Calif.

BRAY, ULRIC B., Consulting Chemist, Alox Corp., 1758 W. Florence Ave., Los Angeles, Calif.

SHELDON, E. L., Physicist, Ryan Aeronautical Co., San Diego, Calif. For mail: 260 Third Ave., Chula Vista, Calif.

STRINGFIELD, RAYMOND B., Head, Materials and Processes Dept., Vultee Aircraft, Inc., Vultee Field, Calif. For mail: 229 S. Normandie Ave., Los Angeles, Calif.

WHITNEY, GEORGE W., Chief Metallurgist, Emsco Derrick and Equipment Co., 6811 S. Alameda St., Los Angeles, Calif.

St. Louis District

VIGNE, ALBERT, President, Bronze Alloys Co., 6264 St. Louis Ave., St. Louis, Mo.

U. S. and Possessions

Other than A.S.T.M. Districts

BEECH AIRCRAFT CORP., M. A. Chester, Assistant Chief Engineer, Wichita, Kans.

BOSTON WIRE STITCHER CO., Arthur Maynard, Engineer, East Greenwich, R. I.

CESSNA AIRCRAFT CO., Wichita, Kans.

GATES RUBBER CO., THE, C. H. Mingle, Technical Director, 999 S. Broadway, Denver, Colo.

RHEEM MANUFACTURING CO., R. M. Thomas, Director, Research Division, 1209 E. Twenty-fifth St., Baltimore, Md.

STANDARD AIRCRAFT PRODUCTS, INC., THE, John E. Golob, Chief Engineer, 121 Franklin St., Dayton, Ohio.

BAUMAN, EDWIN R., Metallurgical Engineer, War Dept., U. S. Army Ordnance, Detroit Ordnance District, Grand Rapids, Mich. For mail: Route 1, Marne, Mich.

BENNETT, ROBERT P., Chief Draftsman, Bendix Aviation Corp., Bendix Radio Division, Towson, Md.

BLAUT, SAMUEL J., Metallurgical Engineer, Bulova Watch Co., 33 Waldo St., Providence, R. I.

BOTSFORD, CARL F., Construction Engineer, State of Nebraska, Board of Control, Lincoln, Nebr.

BRITISH AIR ATTACHÉ, H. N. Thornton, Air Commodore, British Embassy, Washington, D. C.

HALL, WILLIAM D., Chief Engineer, Aeronca Aircraft Corp., Middletown, Ohio. [J]

HART, R. DANIEL, Yonge & Hart, Architects and Engineers, Box 928, Pensacola, Fla.

HAUEISEN, B. R., Consulting Engineer, B. R. Haueisen Laboratory, R4, Box 346, Indianapolis, Ind.

HOFFMAN, RUDOLPH, Chief Chemist, Skenandoa Rayon Corp., Utica, N. Y.

JOHNSON, ARNOLD I., Supervisor of Testing, Omaha Steel Works, Shell Plant, Omaha, Nebr. For mail: Apartment 5, 415 N. Forty-ninth St., Omaha, Nebr. [J]

JOHNSON, Harry V., Development Engineer, National Carbon Co., Inc., Niagara Falls, N. Y.

KELLOGG, FREDERIC H., Senior Materials Engineer, Tennessee Valley Authority, 606 Union Building, Knoxville, Tenn.

KENT, WILLIAM B., Chemical Supervisor, The Mathieson Alkali Works, Inc., Saltville, Va.

KIEHLE, WILLIAM D., Engineer, Eastman Kodak Co., 343 State St., Rochester, N. Y. [J]

MELLENGER, EDMUND REX, Surveyor, Lloyd's Register of Shipping, 1270 Niagara St., Buffalo, N. Y.

MUSCH, HENRY, 3D, Assistant to the Engineering Officer, Watervliet Arsenal, Watervliet, N. Y. For mail: 1923 Highland Ave., Troy, N. Y.

NEBRASKA DEPARTMENT OF ROADS AND IRRIGATION, R. E. Bollen, Testing Engineer, 106 Mechanic Arts Building, University of Nebraska, Lincoln, Nebr.

PRATT, ROYDON S., Metallurgist, Bridgeport Brass Co., Indianapolis Ordnance Project, Indianapolis, Ind.

RODGERS, JOHN A., Engineer in Charge, Physical Testing Laboratory, Stromberg-Carlson Telephone Manufacturing Co., 100 Carlson Road, Rochester, N. Y.

SHOBECK, ARTHUR E., President and General Manager, Jamestown Malleable Iron Corp., Jamestown, N. Y.

SMITH, WILEY C., Chemist, Naval Stores Research Division, U. S. Department of Agriculture, Bureau of Agricultural Chemistry and Engineering, Washington, D. C. For mail: 2101 N. Rolfe St., Arlington, Va.

STEWART, DANIEL L., JR., Ordnance Inspector, War Dept., Birmingham Ordnance District, Birmingham, Ala. For mail: 1325 Fourteenth Ave., S., Birmingham, Ala.

TISLOW, OSWALD ALBERT, Architect and Engineer, 818 Architects Building, Indianapolis, Ind.

UNDERWOOD, CARL M., Manager, Welding Dept., Northern Pump Co., Columbia Heights P. O., Minneapolis, Minn.

URSCHEL, HAROLD C., Vice-President and Engineer, Urschel Engineering Co., Bowling Green, Ohio.

WELCH, L. E., Metallurgist, The Ohio Steel Foundry Co., Springfield, Ohio. For mail: 1112 N. Fountain Ave., Springfield, Ohio.

WILHELMSEN, H. P., President and General Manager, W. S. Dickey Clay Manufacturing Co., New York Life Building, Kansas City, Mo.

WILLSON, C. A., Chief, Civil Engrg. Sec., Specifications Branch, Conservation Div., WPB, Washington, D. C. For mail: 2900 Connecticut Ave.

PERSONALS

* * * News items concerning the activities of our members will be welcomed for inclusion in this column.

R. W. MILLER, formerly Chemical Engineer, Pittsburgh Plate Glass Co., Columbia Chemical Division, Barberton, Ohio, has been appointed Manager of the Technical Service Department, Columbia Chemical Division, Pittsburgh, Pa.

At the annual meeting of the American Institute of Chemists held on May 16 in Atlantic City, the following two A.S.T.M. members were elected to office: GUSTAV EGLOFF, Technical Director, Universal Oil Products Co., Chicago, Ill., *President;* and FOSTER D. SNELL, President, Foster D. Snell, Inc., Brooklyn, N. Y., *Councilor.*

A. E. WHITE, Director of Department of Engineering Research and Professor of Metallurgical Engineering, University of Michigan, Ann Arbor, Mich., has been nominated as a Manager of the American Society of Mechanical Engineers for 1943.

JOHN STEARNS, formerly Assistant Project Manager, Army Post Contractors, Oakland, Calif., is now Assistant Manager of Construction, W. A. Bechtel Co., Marin Ship Division, San Francisco, Calif.

M. F. SKINKER, who was Associate Director of Research, Consolidated Edison Co. of New York, Inc., Brooklyn, N. Y., is now Chief Development Engineer, Selenium Rectifyer Division, International Telephone and Radio Manufacturing Co., East Newark, N. J.

CHARLES ROBERTS, who since 1936 has been the Pittsburgh representative for the H. C. Nutting Co., Engineers and Chemists, has given up this work as a full-time position for the duration. He is now connected with the Toolthrift Co., Pittsburgh, Pa., as Engineer.

Several A.S.T.M. members have been elected officers of the American Ceramic Society for 1942–1943: *President:* L. J. TROSTEL, Chief Chemist, General Refractories Co. Laboratories, Baltimore, Md.; *Trustee, Structural Clay Products Division,* FREDERICK HEATH, JR., Secretary, Colonial Clays, Inc.; *Secretary, Ceramic Educational Council:* C. M. DODD, Head, Department of Ceramic Engineering, Iowa State College, Ames, Iowa.

J. W. CHAMBERLIN, formerly Director, Research Laboratory, American Machine and Metals, Inc., East Moline, Ill., is now Manager of Production, Cleaver-Brooke Co., Milwaukee, Wis.

C. M. STERNE is Lieutenant Commander, U.S.N.R., Bureau of Ships, Navy Department, Washington, D. C. He was with the Metropolitan Refining Co., Inc., Long Island City, N. Y., as Chief Engineer.

EDWARD T. BARRON, for the past seven years Manager of the Metallurgical Division, Pittsburgh District, Carnegie-Illinois Steel Corp., has been promoted to Chief Metallurgical Engineer, succeeding C. F. W. RYS, who has been made Chief Consulting Metallurgist under the Vice-President in Charge of Operations. Mr. Rys has been a member of the Society since 1908 and was active particularly in the period before 1930 in many phases of A.S.T.M. work involving ferrous metals. RICHARD W. SIMON has been appointed Manager of the Metallurgical Division, succeeding Mr. BARRON. For the past three years he has been Assistant Manager of that division.

J. M. SHARF, formerly Technical Service Director, American Bottlers Assn., Washington, D. C., has joined the staff of the Armstrong Cork Co.'s Central Technical Laboratory, and will be associated with the Glass and Closure Division.

A. R. HOWE, Vice-President, Ludlow Manufacturing Associates, Boston, Mass., is now working in the Textile Section of the War Production Board, Washington. He has been very active in the work of Committee D-13 on Textile Materials serving on a number of its subcommittees and on the advisory committee.

ALFRED SONNTAG, for many years active in the Society's work when he was with the Riehle Bros. Testing Machine Co. and later with the Riehle Testing Machine Division, American Machine and Metals, Inc., where he was Chief Engineer in charge of testing machine activities, has joined the technical staff of the Baldwin-Southwark Division, The Baldwin Locomotive Works, Philadelphia, Pa.

R. N. ST. JOHN is Engineer, The Coleman Lamp and Stove Co., Wichita, Kans. He was formerly connected with United Laboratories in Wichita, as Director.

CYRIL STANLEY SMITH, who was Research Metallurgist, American Brass Co., Waterbury, Conn., is now Research Supervisor, War Metallurgy Committee, National Research Council, Washington, D. C.

E. I. VALYI, formerly Metallurgist, The Hydraulic Press Manufacturing Co., New York, N. Y., is now connected with Lucius Pitkin, Inc., New York, N. Y.

A. B. DORAN is Consulting Metallurgist, Douglas Aircraft Co., Inc., Santa Monica, Calif. He was Vice-President, Western Research Labs., Los Angeles, Calif.

T. J. DOLAN, who was Assistant Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill., is now First Lieutenant, U. S. Army, Ordnance Dept., Watertown Arsenal, Watertown, Mass.

M. A. WILLIAMSON is now connected with the Remington Arms Co., Inc., Bridgeport, Conn., as Product Metallurgist. He was formerly Metallurgist, Scovill Manufacturing Co., Waterbury, Conn.

F. P. WHITMER, has discontinued his duties as Director of the

Department of Civil Engineering at the University of Pennsylvania, and resumed professional practice at his former business address, the office of Howard C. Baird, Consulting Engineer, 95 Liberty St., New York, N. Y.

At the recent annual meeting of the American Electroplaters' Society W. M. PHILLIPS, Works Managers Committee, General Motors Corp., Detroit, Mich., and Frank Clifton, were awarded the Founders' Gold Medal for their paper entitled "Bright Copper Plating in Acid Baths." C. E. HEUSSNER, Materials Engineer, Chrysler Corp., Detroit, Mich., received honorable mention for his paper entitled "Comparative Tests of Ocean Water Spray *vs.* Standard Salt Spray."

M. M. BECKWITH is serving in the U. S. Army, Ordnance Department for the duration, but his permanent connection is Development Engineer, The J. B. Ford Sales Co., Wyandotte, Mich.

J. R. FRITZE, formerly Engineer of Materials, Edison General Electric Appliance Co., Chicago, Ill., is now Conservation Specialist, War Production Board, Washington, D. C.

G. C. ERNST, who was Assistant Professor of Civil Engineering, College of Applied Science, Syracuse University, Syracuse, N. Y., is now Civil Engineer, U. S. Forest Products Laboratory, Madison, Wis.

Catalogs and Literature Received

THE BALDWIN LOCOMOTIVE WORKS, BALDWIN SOUTHWARK DIVISION, Philadelphia, Pa. A twenty-page booklet entitled "The Southwark Line of Testing Equipment." Describes Universal testing machines, cement testing machines, stress-strain recorders, fatigue testing machines, strain gages, torque meters, impact tester, oscillator, etc. Illustrated.

COLEMAN ELECTRIC CO., INC., 310 Madison St., Maywood, Ill. Bulletin No. 104, "New Instruments for a Modern World," describes Coleman pH electrometers, industrial pH testers, continuous flow electrode assembly, special glass electrodes for medical research, titration assemblies, electrodes, titrimeters, the photofluorometer, and spectrophotometers. 19 pages, illustrated.

GEORGE SCHERR CO., INC., 128 Lafayette St., New York, N. Y. A leaflet describing the new Magni-Ray developed for close inspection of all parts entering airplane construction. Two pages, illustrated.

FEDERAL PRODUCTS CORP., 1144 Eddy St., Providence, R. I. A print showing Model K P-96, together with description and specifications. This gage is designed for checking 500-lb. demolition bombs.

Also, a print describing Model 45 B-80 pitch diameter gage, for inspecting pitch diameters of all kinds of threads. Illustrated.

Federal Products has also issued a new catalog covering "Shell Dial Indicator Inspection Gages" which includes cartridge cases, projectiles, primers, fuses, bombs and small arms, and ammunition. 30 pages, illustrated.

THE EMIL GREINER CO., 161 Sixth Ave., New York, N. Y. "New and Improved Laboratory Instruments"—first supplement to the ninth edition of the company's General Catalog. Includes descriptions of Pyrex and miscellaneous glass and porcelain ware, general and petroleum apparatus, thermometers, hydrometers, and other apparatus. 72 pages. Illustrated.

C. J. TAGLIABUE MANUFACTURING CO., Park and Nostrand Aves., Brooklyn, N. Y. A 36-page catalog entitled "TAG Celectray Pyrometers, High Speed Photo-Electric Action"—Catalog No. 1101 G—describes photoelectrically balanced recorders, indicators, controllers, recording controllers, potentiometers for thermocouples, slide-wire wheatstone bridges for resistance thermometers, and other new and improved equipment. Illustrated.

Also, a 35-page booklet entitled "TAG Non-Indicating Temperature and Pressure Controllers," Catalog No. 900E. Descriptions cover a number of controllers including: air-operated vapor tension, single system temperature, perfect temperature, automatic time, simplex pressure, and others. Illustrated.

FISHER SCIENTIFIC CO., 711-723 Forbes St., Pittsburgh, Pa., and EIMER & AMEND, 633-635 Greenwich St., New York, N. Y., have issued a new catalog entitled "Modern Laboratory Appliances"—No. 90, which presents combined facilities of both Fisher and E. & A. It covers a wide range of materials and apparatus for chemical, metallurgical, and biological laboratories, is well arranged and profusely illustrated, with descriptive material in sufficient detail to give those interested a good conception of just what a specific item covers.

Of course, in any detailed list of laboratory equipment, there will be a large number of references to A.S.T.M. and that is true in this new volume with one part of the index devoted to descriptive terms arranged alphabetically, and another list in numeric sequence of A.S.T.M. serial designations. The apparatus and materials covered are arranged alphabetically in the book, and each page has a running head so that this serves also as an alphabetical guide and facilitates reference. An apt quotation from Louis Pasteur is imprinted on the binding sheet. This follows:

"Take interest, I implore you, in those sacred dwellings which one designates by the expressive term: laboratories. Demand that they be multiplied, that they be adorned. These are the temples of the future—temples of well-being and of happiness. There it is that humanity grows greater, stronger, better."

LEEDS & NORTHRUP CO., 4934 Stenton Ave., Philadelphia, Pa. "Modern Precision," a new publication of general interest to engineers, research scientists, executives and users of electrical instruments, controls and furnaces. It contains news of L&N instruments, controls and heat-treating methods, and it supplements the regular catalogs, bulletins, and circulars which will continue to be issued as before. 16 pages, illustrated.

CARL SCHLEICHER & SCHUELL CO., 116 West 14th St., New York, N. Y. Descriptive Bulletin No. 65 entitled "S&S American Filter papers for Laboratory Use." This eleven-page pamphlet lists filter papers for qualitative and semi-quantitative analysis, quantitative analysis, and specialties for use in filtrations, in spot tests, and in other laboratory technique.

ALSOP ENGINEERING CORP., Milldale, Conn. Catalog 242, a 15-page folder entitled "Alsop Hy-Speed Filter Equipment Filter Sheets." Describes the new "Sealed Disc" Filter, filter discs, large capacity units for continuous filtration, centri-poise pumps, round plate and frame filters, water filters, internal pressure filters, etc. Illustrated.

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